COMMONWEALTH LAND TRANSPORT BOARD.

AUSTRALIAN STANDARD GARRATT LOCOMOTIVE

FOR

3'6" GAUGE RAILWAYS.

OPERATING MANUAL.

Issued September, 1942.

By Authority:
L. F. Johnston, Commonwealth Government Printer, Canberra.
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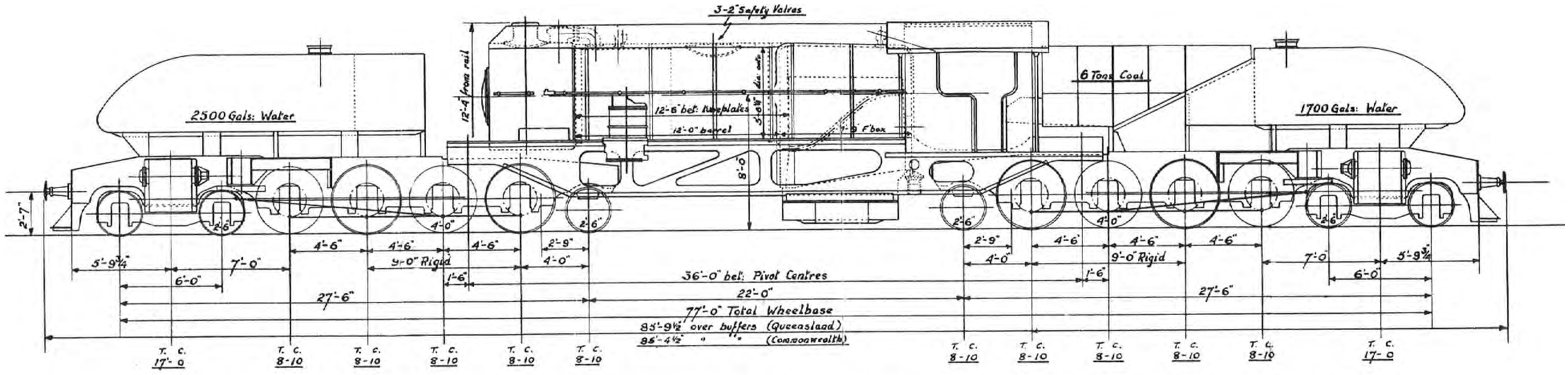
INTRODUCTION.

The Garratt principle was invented more than thirty-five years ago as a means of increasing the power of locomotives without the necessity of spending large sums of money in strengthening tracks and bridges. Locomotives operating on smooth steel rails depend on the friction between the wheels and rails for transmission of power and this condition places a limit to the pulling force or tractive effort which can be exerted. When the force applied exceeds the frictional resistance slipping occurs and the locomotive is useless for train haulage. Since the strengths of the tracks and bridges limit the weight which can be placed on a pair of wheels, the power of the locomotive is related closely to the number of its coupled wheels, and since it is usually not practical to couple more than eight wheels together, the ordinary engine with tender is limited to the power which can be transmitted by eight wheels. In the Australian Standard Garratt Locomotive there are two groups of eight coupled wheels so that the power transmitted is double that of an ordinary engine. The principle has been applied extensively and hundreds of Garratt locomotives are in operation with great success on railways spread all over the world. The Australian Standard Garratt Locomotive is a further application of the same principle and is the only means of gaining the much needed increase of haulage power since relaying of tracks and rebuilding of bridges is quite impracticable in war time. This engine has been designed to operate on any of the 3′ 6″ gauge railways in Australia. It is unique in two ways. It is the first real approach to a standard Australian locomotive and is the first Garratt locomotive to be designed and built entirely in the Southern Hemisphere.



Cylinders	4 - 14¼" x 24"	Tubes	184 - 1¾" dia:	Superheating Surface	315 sq: ft:	Water Capacity	4200 Gals:
Piston Valves	8" dia:	Flues	28 - 5¼" dia:	Grate Area	35 sq: ft:	Coal Capacity ("water level")	6 Tons
Max: Valve Travel	6"	Heating Surfaces Tubes	1054 sq: ft:	Tractive Effort at 85% W.P.	34,420 lbs	Total Weight in Working Order	119 Tons
Max: Cut-off	80%	Flues	481 sq: ft:	Adhesive Weight	68 Tons	Weight per foot run Engine Unit	2·163 Tons
Coupled Wheels	4'-0" dia:	Firebox & Arch Tubes	163 sq: ft:	Factor of Adhesion (Tanks Full)	4·4	Weight per foot run Total Wheelbase	1·545 Tons
Working Pressure	200 lbs per sq: ins	TOTAL	1698 sq: ft:				

FIG 1

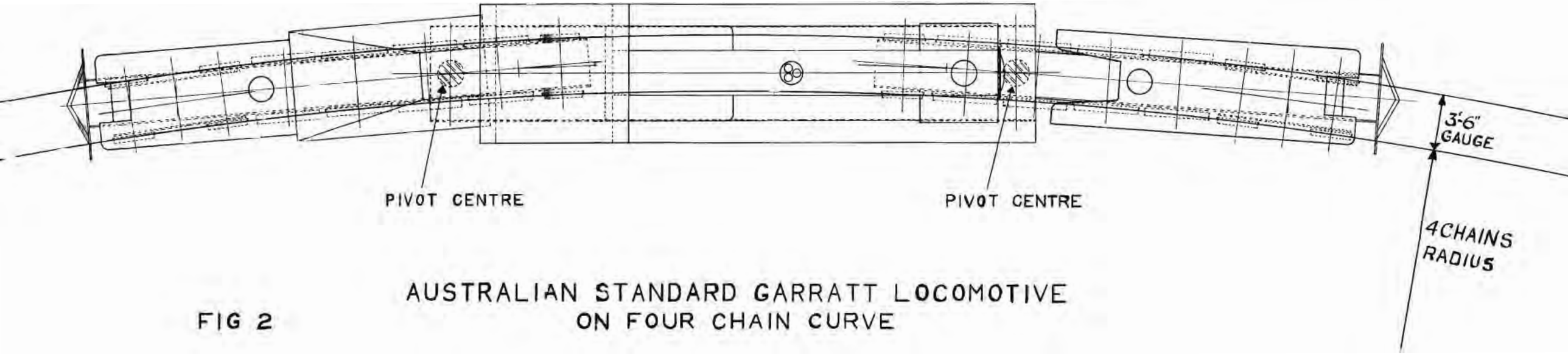


FIG 2

AUSTRALIAN STANDARD GARRATT LOCOMOTIVE
ON FOUR CHAIN CURVE

GENERAL DESCRIPTION.

The principal dimensions of the engine are shown on the outline diagram Figure 1 and it will be seen that the wheel arrangement is 4–8–2–2–8–4. Being provided with a four-wheeled bogie at each end, the locomotive can run equally well in either direction. There is no tender, the coal and water being carried on the engine itself which comprises three main units, namely, the front engine unit, the boiler unit, and the hind engine unit which carries the bunker.

The boiler unit is carried on two pivot centres, placed one on each engine unit, so as to give the flexibility required when travelling over curves and crossings. These pivot centres are very similar to the familiar bogie centre and act in effect as large hinge pins (the diameter of each centre is 20″ and the depth of bearing is $4\frac{3}{4}$″). The principle is illustrated in Figure 2 which shows the engine on a four chain curve. An incidental advantage of the Garratt locomotive is its peculiarly easy riding due to the cab being mounted on a unit which is slung like a carriage between two bogies.

The boiler is of ample capacity with excellent steaming power under all working conditions. Large steam pipes, simple cylinders with short direct ports, long travel piston valves of generous size and well-proportioned Walschaert valve gear combine to ensure efficient use of the steam generated. The steel firebox is fitted with two arch tubes to improve water circulation and very generous water spaces have been provided. A simple saddle of steel plates attached to the smokebox serves to secure the boiler to the boiler cradle frame and the expansion bracket takes the form of two bearings secured to the rear end of the foundation ring. These bearings are of generous proportions and provision for lubrication has been made.

Looking through the front windows of the cab, only the corners of the front tank can be seen since this tank has been made narrower than the smokebox.

In the same way, the hind tank has been made narrower than the bunker which is less in width than the cab. The essential need for a good lookout has thus been met.

The cab itself is particularly roomy and well provided with ventilation. Hinged windows are fitted both front and back and large openings are provided in the sides. A canvas screen can be lowered at each side to give protection in wet weather. For protection against the direct rays of the sun the cab roof is extended well forward and backward of the cab proper and is lined with wood inside. Spring seats are fitted for both driver and fireman. A rack extending the full width of the cab affords a convenient place for tucker boxes, &c.

Other features of the engine are described more fully in succeeding pages of this manual.

Steam Flow.

Figure 3 shows the flow of steam from boiler to cylinders and from cylinders to blast pipe. Steam is collected by a slotted pipe placed high in the Boiler and is led by an elbow to the regulator which is mounted on the superheater header. It will be noted that the regulator is placed outside the boiler so that the valve and its gear are accessible without breaking boiler joints or the difficulty of working inside the boiler. The regulator delivers steam by two branches to the superheater header which otherwise is the usual type.

From the superheater header, steam is led by two pipes inside the smokebox which supply the front and hind engine units respectively through elbows placed in the bottom of the smokebox. At each pivot centre there is a ball joint in the steam line to give the necessary flexibility. These ball joints are very simple in

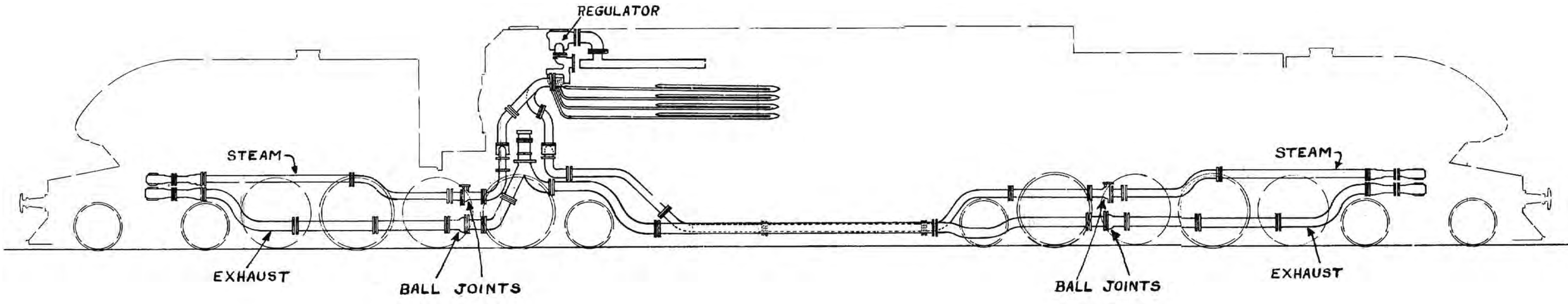


FIG 3 STEAM AND EXHAUST PIPES

character and experience has proved that they give years of service without special attention. From the ball joint the steam is led by steel pipes to the expansion joint which serves also as a Y piece distributing steam to the right and left cylinders. The path of the exhaust steam is very similar. Exhaust branches from the cylinders are joined by the expansion joint from which steel pipes lead to a ball joint at the pivot centre. Under the smokebox the exhaust pipes from the front and hind engine units are joined into a common blast pipe. All joints in the steam and exhaust lines are metal to metal and there is nothing in the system which calls for attention between engine overhauls.

Regulator.

The regulator valve is of the single beat mushroom type with a balancing piston to which steam is admitted by a pilot valve. On starting, the first few inches movement of the regulator handle serves to open the pilot valve admitting steam to the balancing piston of the main valve and a very small supply to the superheater header. The supply to the superheater header is sufficient only for "warming up". In the regulator gear, a compensating lever is provided so that the expansion of the boiler has no effect on the movement of the regulator valve or handle.

It is important that the regulator gear be adjusted correctly to ensure proper closing of the valve. The leverage provided is large and when the valve is nearly closed an appreciable movement of the handle causes only slight movement of the valve. Screw adjustment is provided at the front end of the front pull rod which connects to the lever on the outside of the regulator. This should be the last connexion to be made. To adjust the gear connect up all levers and rods excepting the lever on the regulator and set the handle $\frac{3}{4}''$ clear of the stop for the closed position. Then see that

all slack is taken up and adjust the front pull rod so that the pin connecting to the lever on the regulator can just be tapped into place. If a half turn of the fork end of the rod gives a slack fit, move the handle further from the stop to compensate.

Smokebox.

The smokebox is large in diameter and as long as other features of the engine design will permit to give the greatest possible volume since this has an important effect upon steaming. The blast pipe nozzle is well forward and placed low to give the maximum length of exposed jet while a widely flared petticoat is attached to the base of the chimney for effective entrainment of smokebox gases. A short section of pipe is placed between the nozzle and the main blast pipe casting for ease of assembly and to permit variation in nozzle height should experience indicate that this is desirable.

Smokebox Door.

When opened, the smokebox door is just comfortably clear of the front tank and it will be obvious that provision of a larger door is not practicable. Since a larger opening is essential for removal and renewal of superheater elements and boiler tubes, the entire smokebox front plate is made removable being secured to the angle by bolts. The joint is made with red lead compound which should be scraped off and renewed each time the front plate is detached.

Spark Arrester.

The spark arrester is cylindrical in form, resting on the blast pipe and extending up to the chimney petticoat. About one-third of the arrester nearest the smokebox tubeplate is of solid plate forcing the gases and any sparks to flow round the arrester. The other

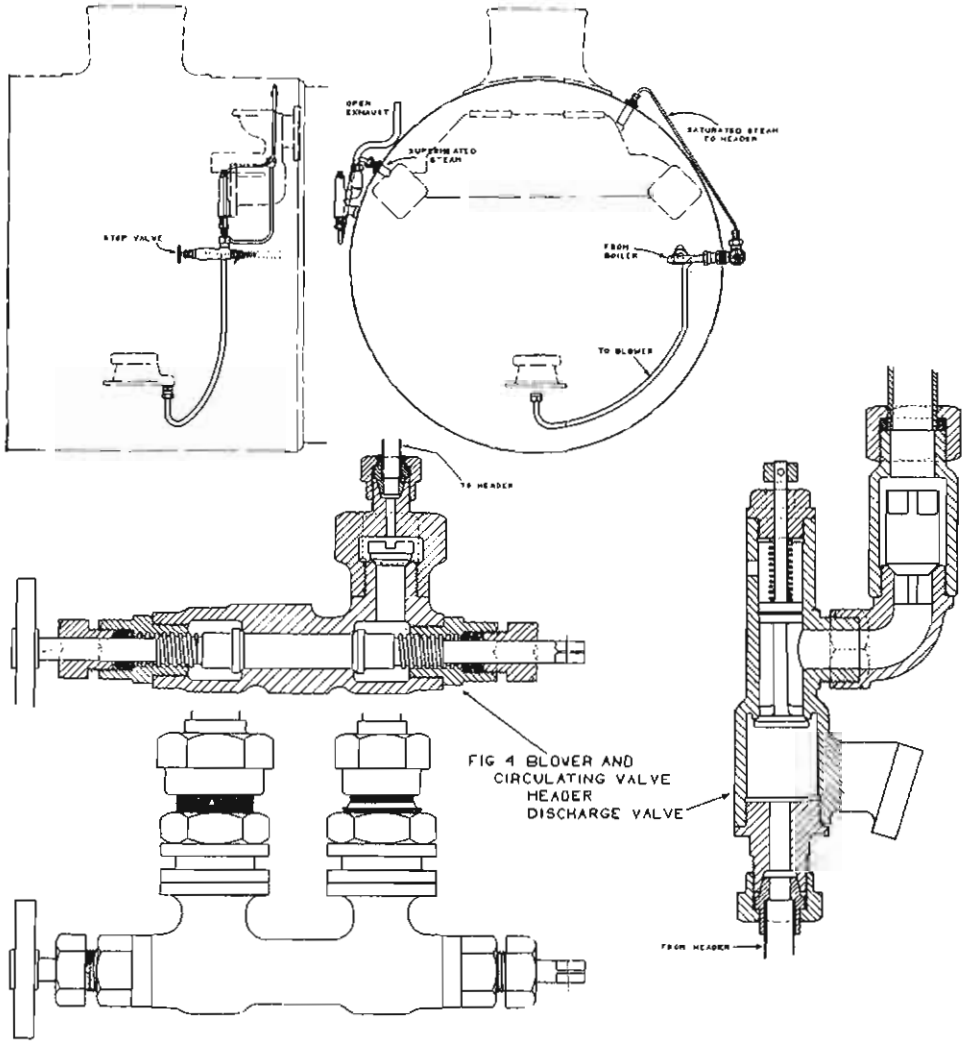


FIG 4 BLOWER AND CIRCULATING VALVE HEADER DISCHARGE VALVE

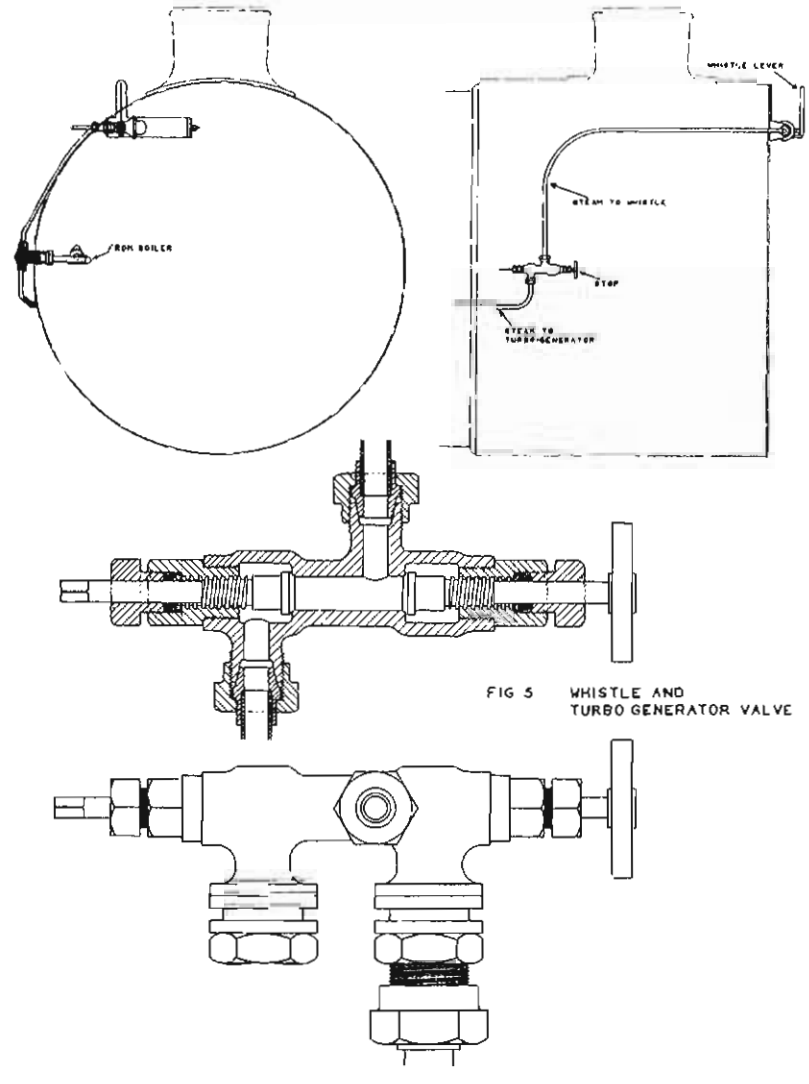


FIG 5 WHISTLE AND TURBO GENERATOR VALVE

two-thirds of the arrester are formed by hinged portions consisting of steel frames covered by wire mesh or perforated plate. Cleaning is thus a simple matter since the arrester can be opened without removing any parts from the smokebox.

Combined Blower and Circulating Valve.

This valve is mounted on the left-hand side of the smokebox and serves to supply steam to the blower, being operated by means of a hand wheel in the cab. When the blower is turned on, steam also flows into the superheater header to provide some cooling for the superheater elements. The flow of steam to the elements is throttled severely. The front hand wheel of the mounting controls a valve which shuts off steam from the boiler, and this valve should always be open when the engine is in traffic.

Header Discharge Valve.

This valve is mounted on the right-hand side of the smokebox and prevents accumulation of pressure in the superheater header and steam pipes while the engine is standing with the blower on. A spring keeps the valve open until the regulator is opened and the supply of steam is sufficient to give 20 lb. per square inch in the header. The system is illustrated in Figure 4.

Whistle and Turbo Generator Steam Valve.

This valve is similar in appearance to the blower and circulating valve but is mounted on the right-hand side of the smokebox and serves to supply steam to the whistle and to the turbo generator of the electric lighting system. There are two valves in the one casing. One valve, controlled by the front hand wheel of the mounting, governs the supply of steam to

the whistle and serves also to shut off steam from the boiler. This valve should always be open when the engine is in use. Steam to the turbo generator is controlled by a hand wheel in the cab. Figure 5 illustrates the valve and its connexions.

Cab Controls.

The positions of the various levers and hand wheels in the cab are shown in Figure 6, which illustrates the arrangement for engines fitted with Westinghouse brake. The purpose of each mounting is clearly marked and the almost complete absence of steam pipes in the cab will be noted. Both for ease of maintenance and for comfort of enginemen the steam stand and its valves, also the exhaust steam injector steam valve and their pipes, have been placed outside the cab.

For engines fitted with vacuum brake the arrangement is even simpler as the only brake mounting is the ejector on the driver's side.

Air Snifting Valves.

Free running or coasting with the regulator closed is of great importance, and to ensure this, a large air valve has been placed on top of each cylinder steam chest. These valves fall from their seats when the regulator is closed and admit air direct to the cylinders as the piston valve opens the steam ports. Coasting should always be done with the engine in full gear as this permits the free admission of air to the cylinders, so preventing back pressure and at the same time ensures even wear of the steam chest liners.

When the regulator is re-opened and steam is admitted to the cylinders, the snifting valves are forced up on to their seats. A small escape of steam before the valve closes is normal and does not indicate a leaking valve.

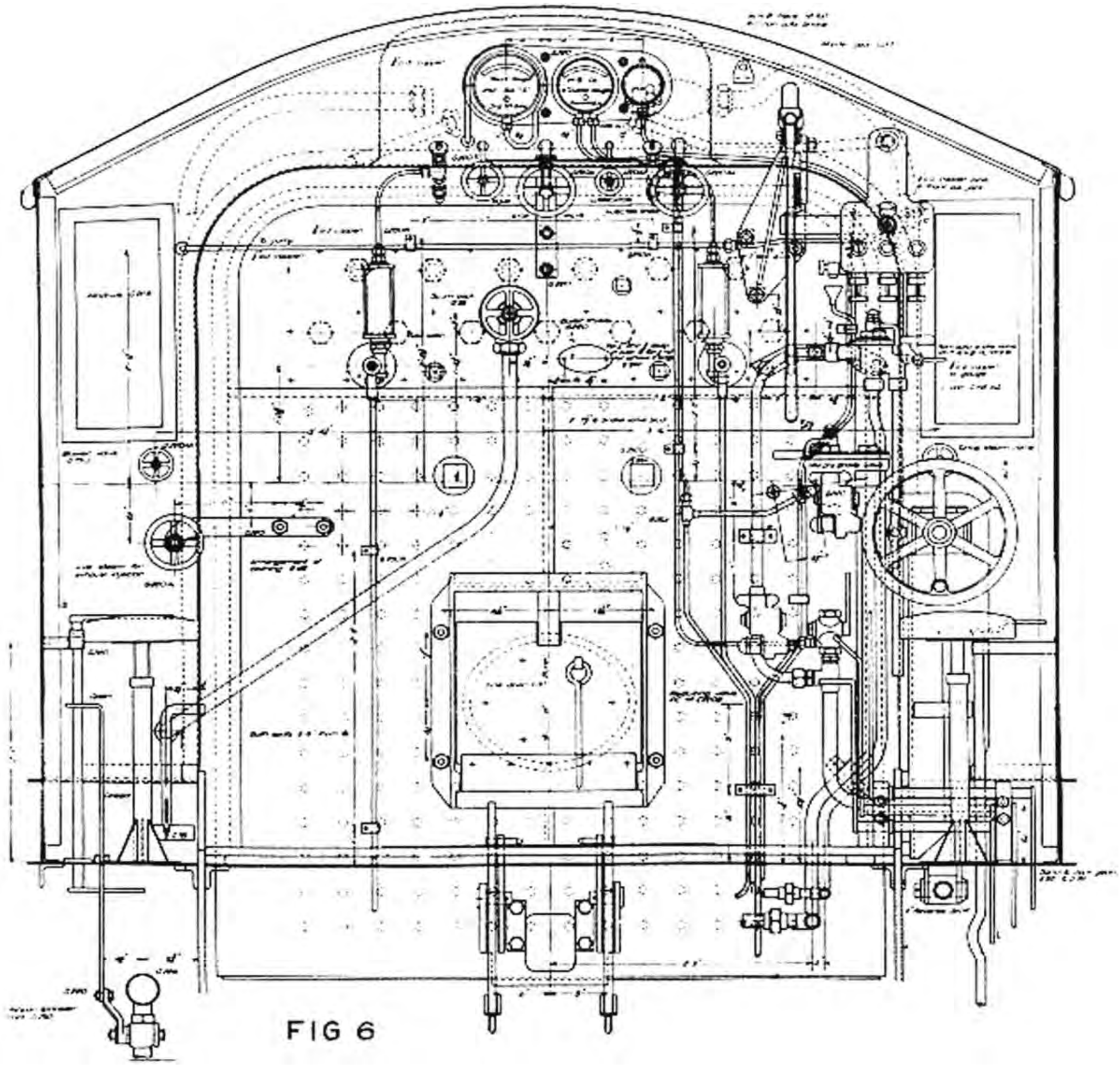


FIG 6

Drain Cocks and Valves.

The usual drain cocks are fitted to each cylinder and are operated by a lever in the cab. Above each drain cock is a ball valve which acts as a drain for condensed steam while the engine is standing or coasting. This ball valve must not be relied upon when starting the engine from rest since it closes automatically when steam is applied. The drain cocks should always be open before the regulator is opened.

Ball drain valves also are fitted to the steam and exhaust pipes to take care of condensation. At one point in the exhaust line there is a $\frac{3}{8}$" diameter hole which is not closed by any valve and exhaust steam escapes from this hole while the engine is steaming.

Valve Gear.

The connecting rod which drives the third pair of coupled wheels is unusually long for an engine of this size and this reduces angularities considerably. In the same way, the eccentric rod and radius rod are of unusual length resulting in reduced angularities and improved valve action. The reversing gear has been arranged so that the reversing link blocks of front and hind engines move up and down together. With the blocks in the bottom of the links the front engine is in fore gear and the hind engine is in back gear. In this condition the engine will run chimney first. When the blocks are lifted to the top of the links, the reverse condition applies, the front engine being in back gear, and the hind engine in fore gear, causing the engine to run bunker first. This arrangement ensures that both engines will be affected equally by wear in the valve gear. The reversing screw handwheel is turned clockwise for full gear chimney first and anti-clockwise for full gear bunker first.

It will be noted that the terms "forward running" and "backward running" need to be applied with great

care when speaking of Garratt locomotives. The expressions "chimney first" and "bunker first" are more explicit.

Maintenance staffs should note carefully that the valve gear of front and hind engines are duplicate in all respects excepting the return cranks attached to the driving crankpins. The return cranks of the front engine differ from those of the hind engine both in length and angle. In the same fashion, the reversing shafts of the two engine units differ, the centre arm being down on the front engine and up on the hind engine.

It is not necessary to disconnect the crosshead and piston rod to renew piston rings. All that is required is to remove the gudgeon pin and push the crosshead up against the gland as this will bring the piston clear of the cylinder. Care must be taken to provide temporary support under the piston rod at the open end of the cylinder and this can be done easily by placing a bar across the cylinder studs. The convenience of this arrangement will be appreciated by all maintenance men.

Permanent centres are fixed in the frames at each side of each axlebox to facilitate overhaul.

Sand Boxes.

The sand boxes are built into the structures which support the slidebars and are arranged to sand the leading pair of coupled wheels. Separate levers are provided in the cab for the front and hind sand boxes. Each sand box holds nearly 2 cubic feet of sand.

Water Tanks.

The front tank of 2,500 gallons capacity and the hind tank of 1,700 gallons capacity are connected by a water-levelling pipe which runs the length of the boiler unit and has rubber hose connections at each pivot centre to give the necessary flexibility. Cocks for

coupling extra water tanks are placed on each buffer beam and are connected to the water levelling pipes, which have been placed low enough to get the full benefit of extra water tanks when attached for long sections. An injector feedwell is placed near the middle of the water-levelling pipe and from this feed-well pipes are led to both injectors. Water cocks are fitted to control the feed to each injector and are operated from the cab.

A filling opening is provided in each tank for convenience in spotting at water columns.

It should be noted that the two tanks are equal in height and the rate of filling should be reduced when the tanks are nearly full to permit proper levelling of the water and complete filling of the tanks.

A recess is formed at the rear of the front tank so that superheater elements and boiler tubes may be withdrawn and renewed without removing the tank.

Bunker.

While in its outer appearance the bunker may not be regarded as a thing of beauty since all stays have been placed outside, the interior is completely free of obstruction and smooth. This facilitates the movement of coal forward and the maximum slope obtainable has been applied to the rear of the bunker. Being carried on the hind engine unit, the bunker moves sideways in relation to the cab when the engine is passing over curves, and the necessary clearance for the coal chute has been provided in the cab back plate. The coal chute has been placed higher than the fire hole so that coal is not lifted when firing.

Blow-off Cock and Scum Cock.

The blow-off cock is mounted on the front plate of the firebox and is operated by a handle which protrudes through the boiler cradle frame. Gear for operating the blow-off cock from the cab has not been provided.

The scum cock is mounted on the back of the firebox and serves to reduce concentration of boiler water and to relieve foaming, should this occur. Both the blow-off cock and the scum cock discharge into a muffler on the right-hand side of the boiler cradle frame. This fitting ensures a quiet and safe discharge.

Whistle.

With a view to the cōmfort of enginemen, the chime-type whistle is mounted on the front of the smokebox, as far from the cab as is practicable. It is operated by means of cords placed within easy reach of both driver and fireman.

For similar reasons, the turbo generator, which so often is placed on top of the firebox, is mounted on the footplate near the smokebox.

Injectors.

On the driver's side (right hand), an ordinary live steam injector is mounted.

The steam valve for this injector is mounted in the steam stand. There is no need to go into any detail regarding the operation of an ordinary injector, but it is worth noting that the instrument is mounted below the foot plate and the water is fed by gravity to the injector.

Forward of the firebox on the fireman's side (left hand) an exhaust steam injector is carried in the boiler cradle frame. This injector operates either with live steam or with exhaust steam and the intention is that it should operate continuously to maintain a uniform water level.

While the locomotive is steaming, this injector is operated with exhaust steam, but when the locomotive is standing or coasting, live steam is used. Naturally

the instrument is started with live steam, the control valve being placed conveniently on the left-hand side of the firebox within easy reach.

The steam valve should be opened fully and not throttled, adjustment being made with the water valve, and this adjustment should be carried out with care since satisfactory operation of the injector depends upon this to a fair extent. Change over from live steam to exhaust steam is automatic and takes place when the supply of exhaust steam is sufficient for the purpose. The change-over valve is an integral part of the injector.

Exhaust steam is led to the injector by a branch from the main exhaust line and the volume of steam so diverted is controlled by a deflector. Provision is made for varying the position of the deflector, but when the best position has been determined, the setting should not be disturbed.

A grease separator is fitted immediately ahead of the exhaust steam injector with a view to removing oil remaining in the exhaust steam before it is used in the injector. This separator should be cleaned out thoroughly when the engine is in the shops for general repairs, but should not otherwise require any attention.

Grate.

The grate is almost square, being 7′ long by 5′ wide, and is covered with Waugh patent fire-bars. These firebars, which provide a rocking grate, take the form of small units mounted on carrier bars carried in turn by carrier bars placed at each side and in the centre of the firebox. The centre carrier bar divides the grate into two and each half of the grate can be rocked independently of the other. The units ar specially designed to provide an even air flow from the ashpan through the fire bed. This assists considerably to minimize clinker. Clinker is fused or molten

ash and dirt accumulated in the fire bed or on the surface of the fire bars. The best method of preventing the formation of clinker is to slightly rock the grate at intervals. Normally the amount of rock obtainable is limited to avoid the danger of dropping a considerable portion of the fire. When the engine is being shed-worked, a small flap in the cab floor plate is lifted and this allows a much greater movement of the grate lever so that the bars can be tilted to an angle of 45 degrees. A few movements of this extreme position usually suffice to drop the whole of the fire into the ashpan. This full movement therefore never should be used except in the shed. Renewals in this grate usually are confined to the small units, the carrier bars, being relatively far from the fire bed, usually have long life.

Ashpan.

The ashpan of large capacity is attached to the boiler cradle frame and not to the firebox. Large dampers at the sides are controlled from the cab and provide for ample air admission under the fire. Very considerable quantities of ash can be carried without any danger of blocking the air openings.

Clearing of the ashpan is carried out by means of a side-hinged door which affords a large opening and avoids any necessity for the unpleasant conditions commonly associated with ash pits. Two flushing pipes supplied from the water-levelling pipe are provided for damping of ashes when raking out ashpan.

Brakes.

Most of the Australian Standard Garratt locomotives are fitted with Westinghouse brake, and on these engines a cross compound compressor is carried on the left hand side of the boiler cradle frame.

Special care must be taken to start the compressor gently and the steam valve should not be opened fully until the air pressure has reached 30 lb. per square inch. This pressure will give satisfactory cushioning for the high pressure piston and ensure proper operation of the compressor governor.

The usual piping connexions are made, the reservoirs being carried under the boiler in the boiler cradle frame. A horizontal brake cylinder is provided on each engine unit. The release valve for the front engine brake cylinder is connected to the cab, using a flexible hose at the front pivot centre. The release valve for the hind engine cylinder is connected by a pipe secured to the coal chute of the bunker, so avoiding the need for a hose at the hind pivot centre. Both automatic and straight air valves are carried on the back of the firebox within easy reach of the driver.

The engines intended to operate on systems where vacuum brake is standard, are fitted with a vacuum brake ejector, having a steam brake valve in conjunction, and steam brake cylinders are provided in lieu of the Westinghouse brake cylinders fitted on other engines.

It will be seen that in these cases, the vacuum brake ejector is required only for exhausting the train pipe system and is not required in connexion with any brake on the locomotive itself.

When the engine is detached from the train, the steam brake can be used independently of the vacuum brake, and when attached to a train the steam brake is operated automatically when the vacuum brake is applied.

A hand brake is fitted only to the hind engine unit. The brake screw handle is fixed to the coal chute to take up a minimum amount of space in the cab.

Exhaust steam from the Westinghouse brake compressor, or the vacuum brake ejector as the case may

be, is led into the base of the chimney. The exhaust from the turbo generator discharges in the same way. Steam discharge in this fashion serves, to some extent, the purpose of a blower, and for this reason use of the blower valve itself should be very infrequent.

Springs and Gear.

All wheels on the locomotive are sprung independently of each other. In the case of the coupled wheels, the springs are underhung since there is not sufficient clearance near the pivot centre for overhung springs. The bogie and trailing truck both have overhung springs. All spring links are fitted with simple cotters proved by experience to give very long service without need of attention. The absence of pins from the spring links carries with it an absence of need for lubrication. There are no compensating beams with their attendant pins, which sometimes are difficult of access. It will be clear that maintenance of spring gear will be very light indeed.

Bogies and Trucks.

Sufficient side movement has been provided in both bogies and two-wheeled trailing trucks to permit the engine to travel over curves of four chains radius. It will be noted that the leading and intermediate coupled wheel tyres have been made flangeless to reduce the rigid wheel base for ease of working over sharp curves. There are no swing links or pins in the control gear of either bogies or trucks. In both cases, control is by direct acting springs so mounted as to act with equal force in either direction. This ensures that while the engine is on straight track, the bogies and trucks will be central without any tendency to run to one side. The absence of swing links and pins obviously means less maintenance.

LUBRICATION.

Cylinders.

Oil is supplied to the cylinders from a sight feed hydrostatic lubricator mounted in the cab. One feed is taken from this lubricator to each of the steam ball joints at the pivot centres. There the oil is atomised and carried by the steam to the cylinders. Experience has shown that this very simple system affords adequate lubrication to the steam ball joint, the piston valves, pistons, and exhaust ball joint. There are no complicated pumps or masses of piping to be considered. The same lubricator has a third feed for the Westinghouse brake compressor. Care should be taken to start the hydrostatic lubricator at least half an hour before the engine is required to join its train. This will ensure the oil being where it is wanted.

Figure 7 illustrates the choke and atomiser fitted to each live steam ball joint. Oil is carried by a small flow of steam from the sight feed lubricator in the cab to the ball joint fitting. Here the flow is restricted by the choke which is drilled with a 1/16″ diameter hole and serves to increase the velocity of flow and alter the intermittent drop feed observed at the lubricator to an almost continuous flow. Emerging from the choke the mixture of steam and oil strikes the head of the atomiser and this tends to break up any globules of oil passed through the choke. The atomiser has two 1/16″ diameter holes at right angles to each other which form the only outlet for the oil-steam mixture. Experiment has proved that the oil issues from the atomiser in the form of a mist which mixes readily with the main steam flowing in the direction of the arrow. From that point onward wherever there is steam there is oil.

Both choke and atomiser are made of hard steel to resist the abrasion and erosion of the steam and will last for a very long time. As the steam which carries

the oil from the lubricator to the choke is not superheated there is very little risk of carbonisation. On rare occasions foreign matter carried in the oil will block the small holes in the choke or atomiser and this usually is reflected by flooding or some other interference with the sight feed at the lubricator. Whenever the lubricator appears to be working unsatisfactorily the fact should be reported and it is a good plan for maintenance staffs in such cases to make a check on the condition of choke and atomiser the first step in seeking the cause of trouble. Normally the fitting will remain undisturbed for many months, but it should always be checked over during general overhauls and the oil pipes should be blown clear before being coupled up.

The oil feed to the Westinghouse brake compressor is choked at the point of delivery but an atomiser is not fitted.

Sight Feed Lubricator.

Starting.—With the steam valve of the lubricator and the valve in the steam stand both closed see that the lubricator is filled with superheated steam cylinder oil. After replacing the filling plug, open the valve in the steam stand then open the steam valve in the lubricator. Next open the water valve located at the centre of the lubricator body. Oil feed valves must not be opened until the water level has been established. This is easily determined since the rising water can be seen easily through the sight feed glasses.

When the water level has been established, open the oil feed valves on the right and left sides and adjust them to give six drops per minute. The centre valve should then be opened and adjusted to give three drops per minute. These rates should be maintained until the locomotive has completed 1,000 miles of running. Feeds may then be reduced from six to four drops and from three to one drop per minute respectively.

If the sight feed glasses become clouded, close all oil feed valves and open the drains in turn, holding a fire

shovel or other receptacle to catch the discharge. Each drain valve should be kept open until its respective sight feed glass has been blown clear. Do not re-open the oil feed valves until the water level has again been established.

Closing Down.—When starting the locomotive the sight feed lubricator should be shut off in the following manner and strict observance of these instructions is of vital importance as any other method of shutting-off must lead to clouded sight feed glasses on re-starting.

First close all oil feed valves leaving the water valve and steam valves open. This will permit discharge of accumulated oil. If the steam valve is closed first the water in the lubricator will evaporate and the residue of oil will form a thick film over the sight feed glasses.

After closing the oil feed valves, leave the steam and water valves open as long as possible but in any case for a least fifteen minutes after which the water valve may be closed. The last job before leaving the engine is to close the lubricator steam valves.

Re-starting.—After the engine has been standing with the lubricator shut off restarting is the same as starting from cold. It is very important that the lubricator should be started at least half an hour before moving the engine to ensure that oil will reach the ends of the pipes. The steam valves can be opened as soon as the pressure gauge shows 20 lb. per square inch.

Axleboxes.

The system of lubrication is the same in principle for all of the axleboxes, the application to the coupled axleboxes being shown in Figure 8.

It will be noted that there are no wick feeds for journal lubrication and that under feed is relied upon entirely. Wool rolls carried upon a tray in the axlebox keep, maintain contact with the axle journal and so maintain the supply of lubricant. The axlebox is replenished by filling the top, allowing the oil to run through the pipes and the passages in the axlebox brass,

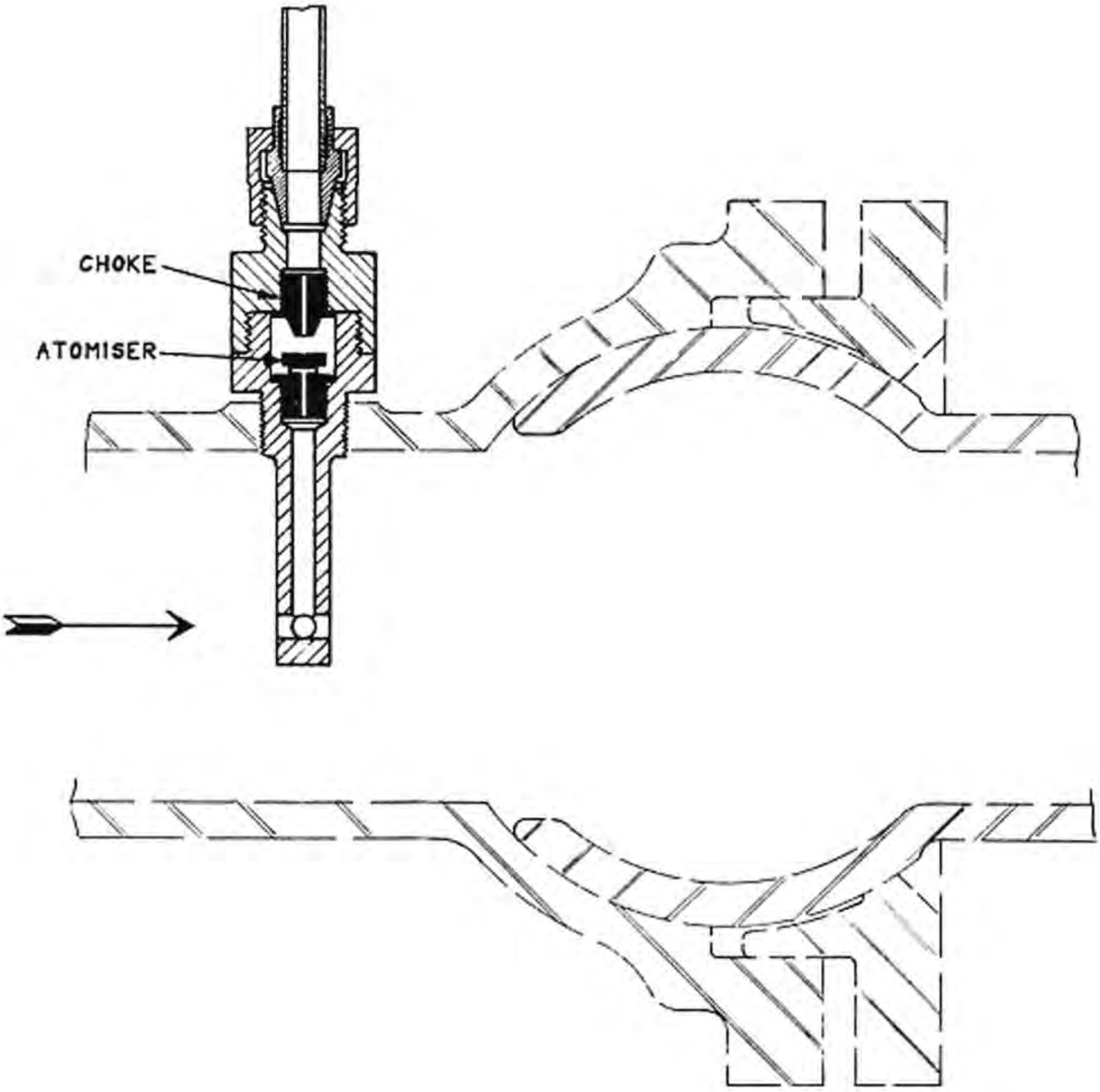


FIG 7 STEAM BALL JOINT OIL FITTING

round the journal into the keep. This system has proved very successful indeed in practice. A small residue is left in the top of the axlebox which serves to afford lubrication to the horncheeks, by means of the ordinary wick feed. As the hornfaces are very wide, enginemen should apply oil with a hand feeder when preparing the engine for traffic.

Great care should be taken in making wool rolls when renewal becomes necessary. Long strands of wool should be used and laid evenly to form a uniform cylinder of correct size. A tube should be used as a gauge to check each roll which should just pass easily. If the roll is slack in the gauge it will not maintain satisfactory contact with the axle journal when in place and rolls which are too tight in the gauge will be too tight in place to allow proper feeding of oil, will be more liable to glazing and will wear rapidly. Proper attention to lubrication is the only way to avoid overheating of a correctly fitted axlebox.

Slide Bars.

The slide bars are constructed so that the bearing surfaces are enclosed entirely and protected from dust. Two oil boxes are provided under each sandbox to afford slide bar lubrication by wick feed.

Connecting and Coupling Rods.

There are no wick feeds for lubricating connecting and coupling rods. Lubrication of the gudgeon pin is by means of an oilbox secured to the little end of the connecting rod with its filler arranged clear of the crosshead. There are no wearing parts in this oil-box requiring attention. Crankpins are lubricated by a method known as pin feed, illustrated in Figure 9.

It will be seen that a pin is fitted into the oil tube with only a few thousandths of an inch clearance, and is free to rise and fall as the wheels revolve. This pin in its movement feeds oil to the bearing. The amount of clearance between the pin and tube is of great importance. A special pin giving greater than

normal clearance is provided for the first 1,000 miles of running to ensure ample supply. During this period, enginemen should be watchful to see that oil cups are kept replenished. After the first 1,000 miles, these pins should be taken out and a larger size fitted. The pins and bushes in which they slide are of hardened steel. Even so, wear must take place eventually. As soon as wear has developed sufficiently to form a noticeable ridge on the pin, even though this be very small, the clearance should be checked and if found greater than standard, the pin should be renewed. At each general overhaul, the sizes of pins and bushes should be checked. The only attention required from the driver is filling of the oil cups.

Valve Gear.

Wick feed oil boxes are provided for the valve spindles and for the trunions of the reversing links. All other oilboxes are of a special type which require replenishment only. This type of oilbox is illustrated in Fig. 10.

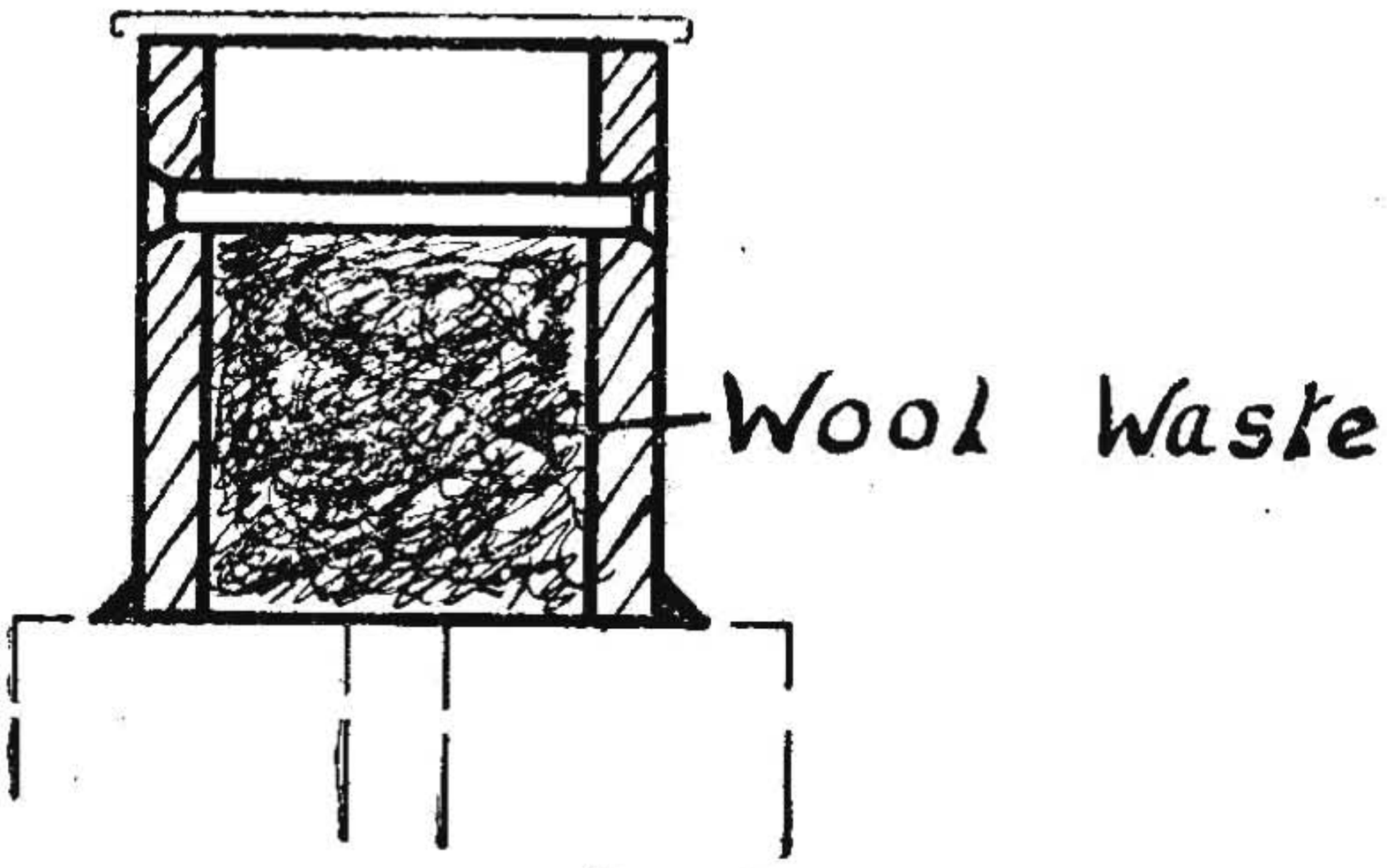


FIG. 10.

It will be seen that the oilbox is packed with a small quantity of wool waste held in place by a riveted pin. When the oilbox is filled up, the oil soaks through the wool and feeds to the bearing gradually. When the waste becomes caked with dust, it should be renewed, care being taken to avoid overtight packing.

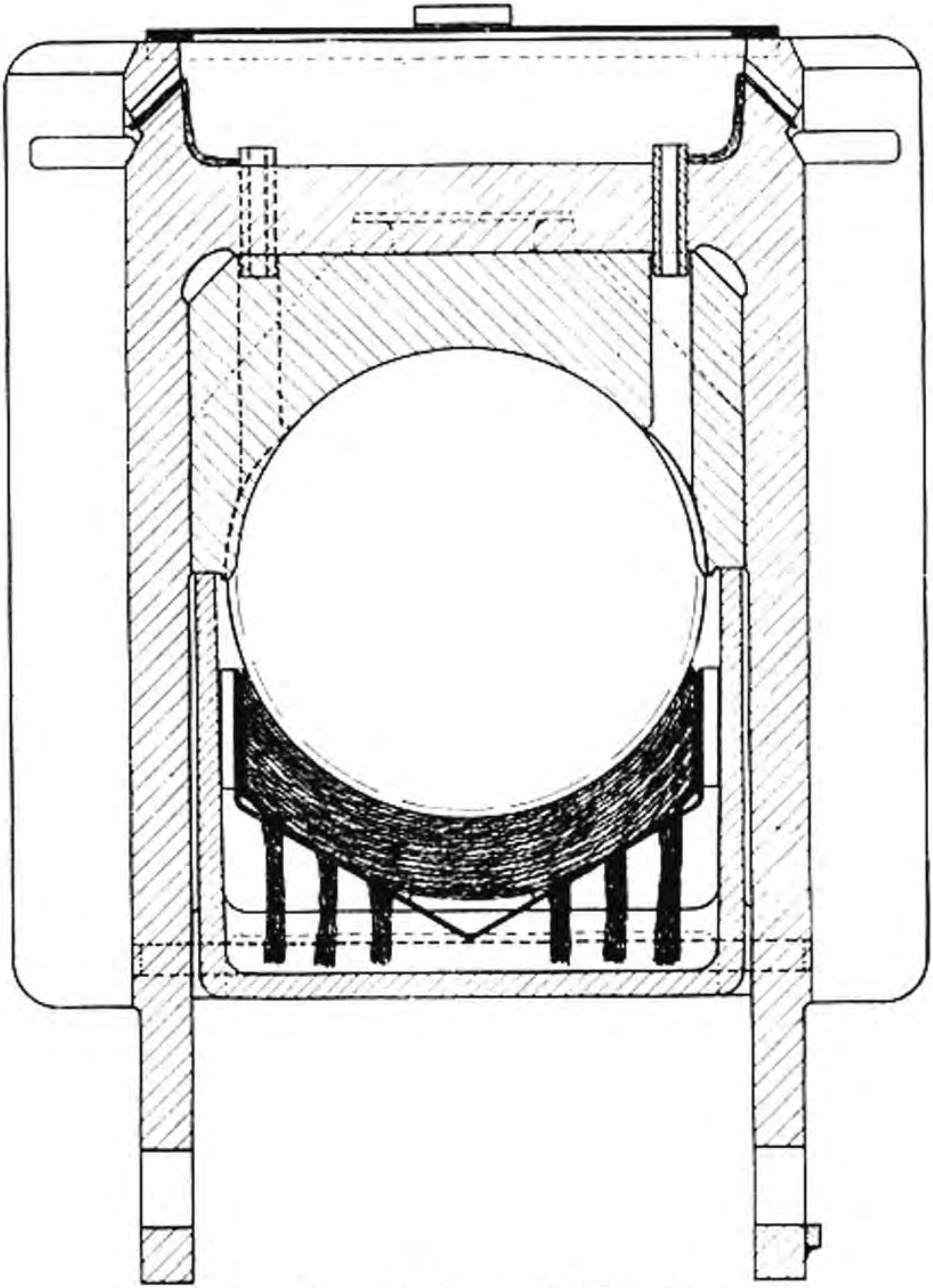


FIG 8 AXLEBOX LUBRICATION

Pivot Centres.

The pivot centres operate in oil baths and do not require any attention for lubrication between engine overhauls. Should the top and bottom portions of the pivot centre be separated during engine overhaul, care should be taken that a sufficient quantity of oil is placed in the lower portion before re-assembly.

Bogie Centres.

The pivot bearing of each bogie centre operates in an oil bath and does not require attention for lubrication between engine overhauls. Should the centre be disassembled during overhaul, care should be taken that a sufficient quantity of oil is placed in the lower portion before re-assembly.

Wick feed oil boxes mounted on the engine frames are provided for lubricating the bogie slides.

Trailing Truck.

Wick feed oil boxes mounted on the engine frames are provided for oiling the control spring plungers.

Reversing Levers.

At each pivot centre there is a horizontal lever serving to connect reversing gear on the engine unit to the boiler unit. Care should be taken to see that the pins in these levers are lubricated when the engine is being prepared for traffic.

Boiler Supports.

At each side of the boiler cradle frame near the back of the firebox and outside the frame plates, a pipe is provided for lubricating the boiler supports. These pipes are surmounted by oilboxes packed with wool waste similar to those provided for the valve gear. As free movement for boiler expansion is of considerable importance, these oilboxes should be filled every time the engine is prepared for traffic.

WASHING OUT.

The importance of regularly and thoroughly cleaning the boiler cannot be over emphasized. Postponing a washout to meet urgent traffic demands always results in worse delays later and a serious rise in maintenance troubles. Nothing else will shorten the life of a boiler so much. It is imperative that the boiler be washed out thoroughly at intervals of six days or at equivalent mileage intervals.

There are ten ordinary washout plugs in this boiler placed as follows:—

Firebox crown: two each side and two in backplate.

Foundation ring: one at each corner.

In the smokebox tubeplate there are four capped washout plugs and a capped plug is placed at each end of each arch tube.

Every plug should be removed every time the boiler is washed out and they should be replaced carefully using the minimum force required to ensure steam-tightness. The threads should be coated with graphite.

Special care should be used to see that the arch tubes are scoured thoroughly.

A partial washout is worse than useless since it gives a false sense of security.

An extra plug is provided in the backplate for filling the boiler.

FUSIBLE PLUGS.

The type of fusible plug fitted which is illustrated in Figure 11 may be new to many enginemen and maintenance staffs. Its effectiveness and efficiency have been demonstrated over many years experience both in New Zealand and in Western Australia.

When discussing fusible plugs, it is as well to keep their true purpose firmly in mind. A fusible plug is not just a trap for an unwary fireman, but is a safety

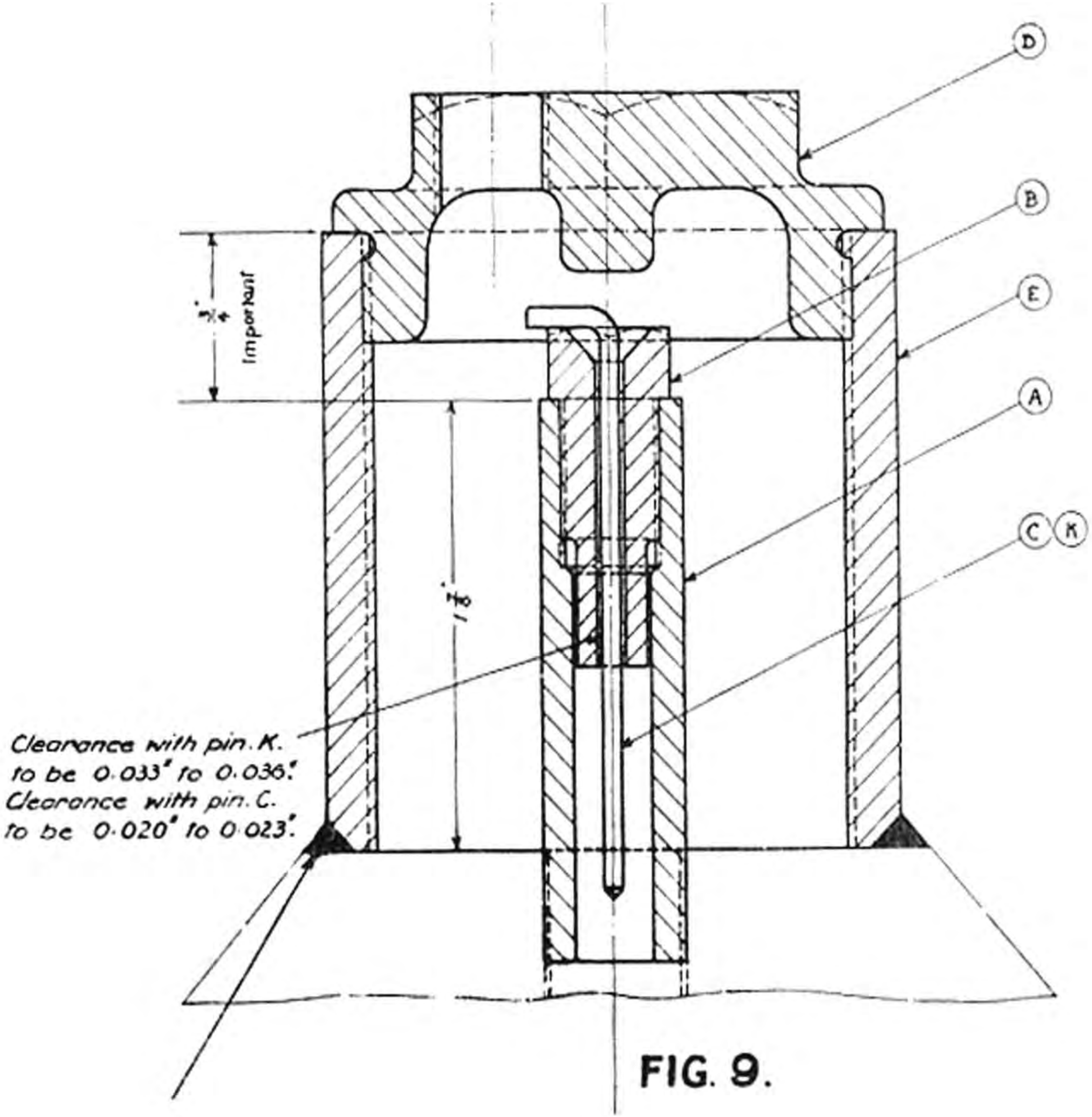

D
B
E
A
C
K
Important
1⅛"
Clearance with pin. K.
to be 0.033" to 0.036".
Clearance with pin. C.
to be 0.020" to 0.023".

FIG. 9.

device designed to prevent boiler explosions and to protect boilers against damage due to steaming with the water level too low. If the firebox crown is uncovered while steam is being generated, the material of the crown, in this case steel, becomes overheated and weakened and consequently less able to sustain the pressure in the boiler. In extreme cases the plate is torn from the crown stays with great violence and a disastrous explosion takes place being accompanied almost invariably with loss of life. Prevention of such disasters is the purpose of fusible plugs.

It should be remembered that a fusible plug, like a safety valve, is intended to deal only with abnormal conditions and should never operate when the engine is being handled properly.

Examination of Figure 11 will show that the amount of fusible metal is small and takes the form of a liner between a solid plug and the body of the plug. This liner is made from a special alloy which will not melt under ordinary boiler temperatures but will soften quickly if deprived of surrounding water to keep it cool. The construction is such that when the liner is almost molten and so very weak, the solid plug is blown clean through the body on to the grate. Thus a hole is formed which will not become partially closed by partial re-setting of the fusible metal and relief of pressure is certain. Complete protection is thus ensured.

The largest member of the fusible plug assembly is intended to remain permanently in the firebox crown to afford a seating into which the plug body proper can be screwed. As the threads have been bedded together it is sufficient to screw the plug hand tight and quite unnecessary to exert considerable force on the wrench. This is important because each fusible plug should be examined and the liner should be renewed by a responsible officer every sixth week. At each renewal the threads should be coated with graphite.

To renew a liner the plug is removed from its seating and the small solid plug is tapped out. The liner can then be tapped out and should at once be flattened with a hammer so that it cannot be re-used by mistake. The quantity of metal involved is so small that no attempt should be made to salvage used liners. They should be destroyed and discarded as soon as removed. The new liner is placed in the plug body and followed by the solid plug which is firmly but lightly hammered into its place. This ensures just enough deformation of the liner to make it bed properly both to the plug body and the solid plug so forming steam tight joints. The assembled plug can then be screwed into its seating.

Frequent renewal of liners is insisted upon not from any fear that the character of the metal will undergo any change but to make certain that there is no incrustation by water deposits which will prevent proper cooling.

SAFETY VALVES.

Three safety valves of the "pop" type are mounted on the manhole cover near the centre of the boiler. Two valves are muffled. One muffled valve is set to blow at 205 lb. per square inch and the other two valves are set to blow at 208 lb. per square inch. It is thus possible to maintain the full working pressure of 200 lb. per square inch without causing safety valve discharge. Experience may indicate that both muffled valves should be set at 205 lb. per square inch, but it is hoped that this can be avoided and rotation of setting be adopted. The valves should be tested regularly by forcing the pressure to blow-off point and at suitable intervals the settings of the muffled valves should be changed over so that each will get its fair share of work.

TOOLS.

A full kit of tools is provided with each engine and includes spanners for every nut and bolt, fireirons, pinch bar, four traversing screw jacks with ratchet

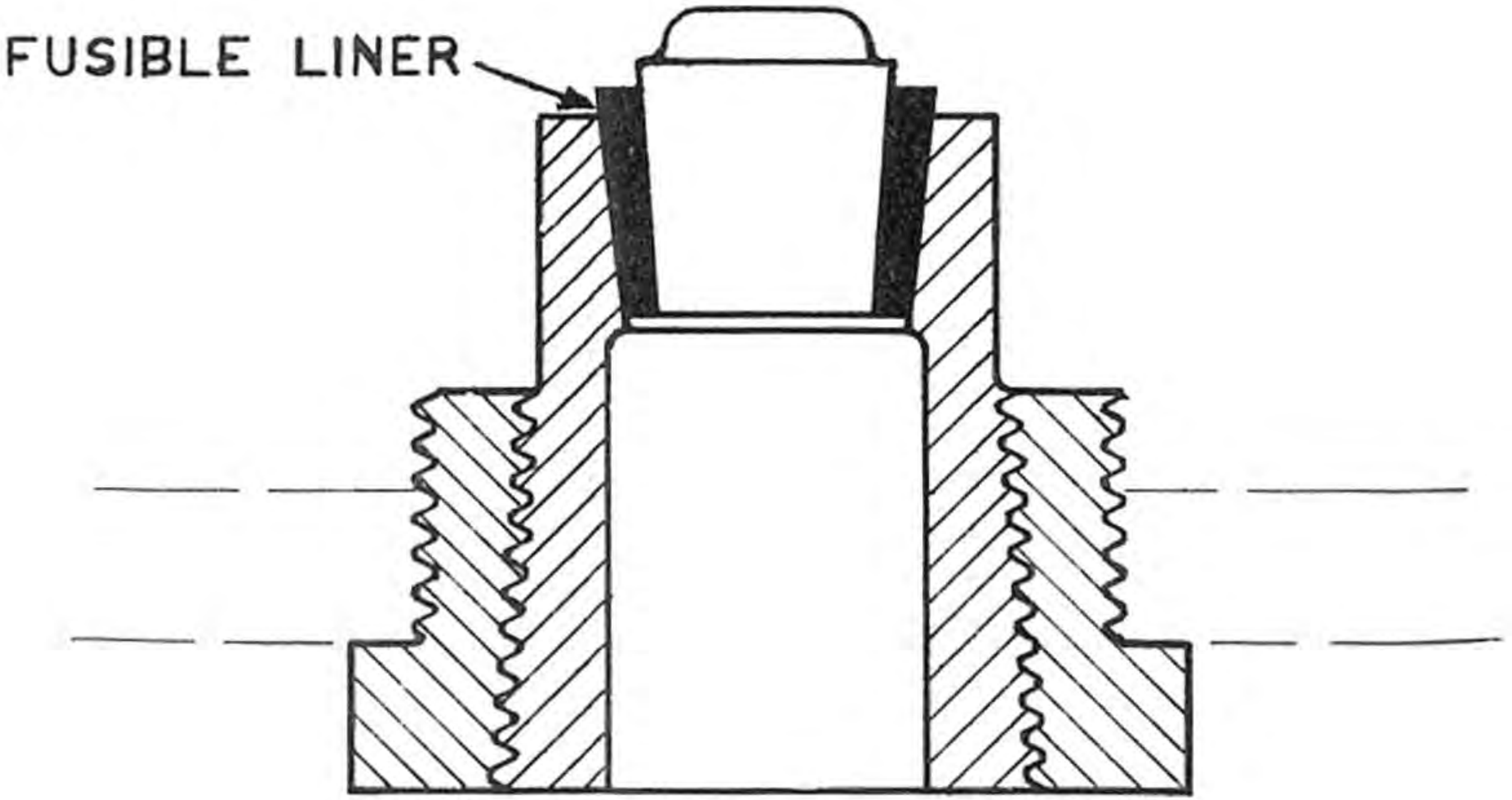


FIG 11 FUSIBLE PLUG

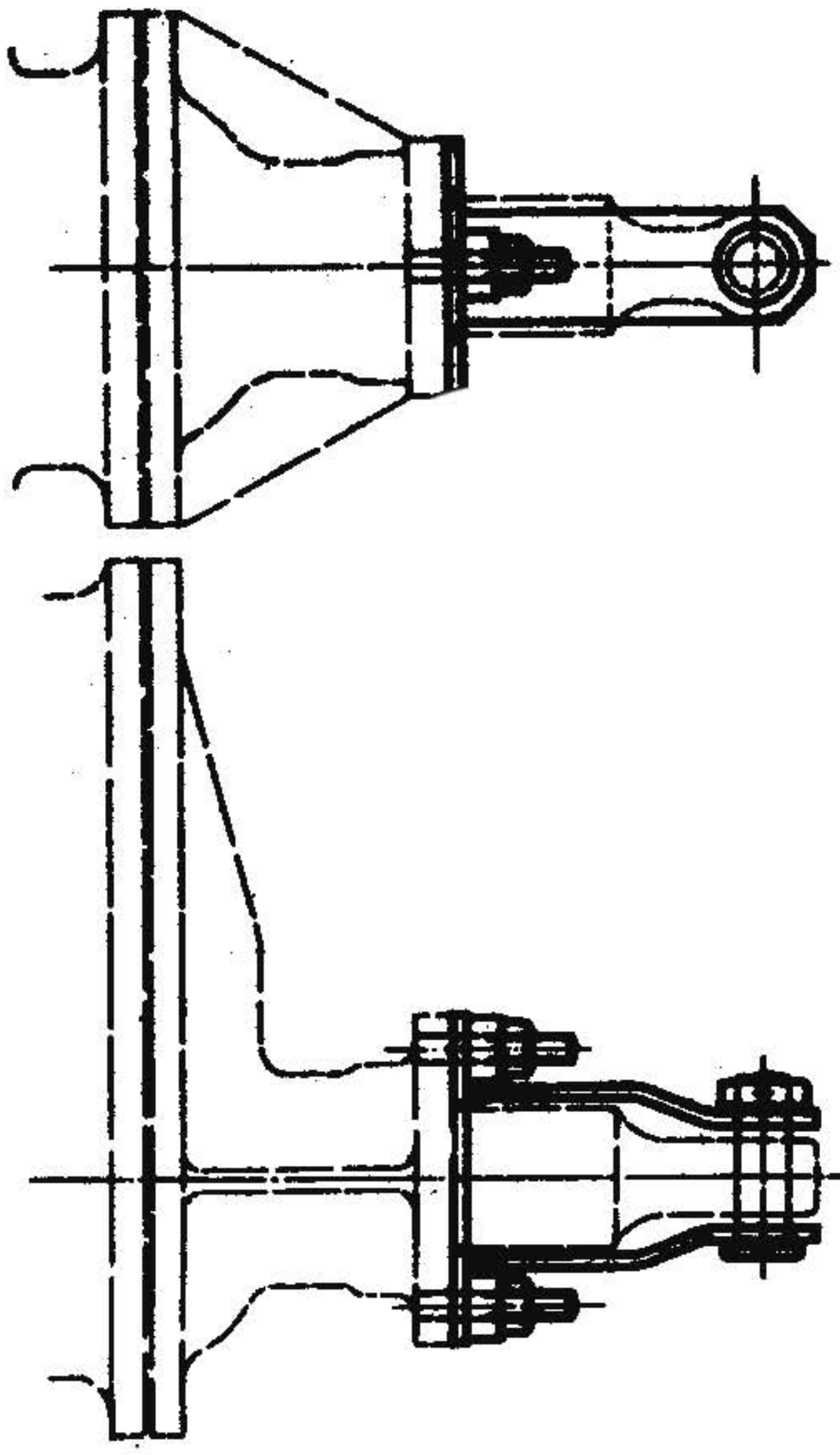
levers and tommy bar, one bottle-type screw jack with tommy bar, and spanners for washout plugs and caps. The traversing screw jacks are carried on the footplate and should be kept covered to ensure they will be in workable condition if and when required for use.

Clamps for centring both valve and piston are provided and are illustrated in Figure 12. To centre the piston valve disconnect and remove the lead lever (sometimes called the combination lever), the radius rod and crosshead link. Then remove the gland and gland plate from the back steam chest cover and put the clamp in its place as shown in Figure 12 and secure the valve spindle by means of the pin removed when taking the lead lever down. This automatically puts the piston valve in its central position.

While it is not necessary that the pistons be centred, it is essential that it be held against movement when the side has been taken down and in this case it is more convenient to clamp the crosshead in its central position than in any other. All that is required is to fasten a clamp at each side of the slidebar bracket with the crosshead in between putting the clamps as close to the crosshead as possible. Movement in either direction is thus prevented and there is no need for improvised wood packing or the like.

MAINTENANCE.

The following notes are intended for the guidance of maintenance staffs to whom the locomotive will, at first, be strange. Care has been taken to keep the construction as simple and accessible as possible with a view to easy maintenance. It should be remembered that no matter how carefully a locomotive is designed or built reasonable care in use and prompt attention to all adjustments and repairs required are essential for satisfactory and continuous use. While it is true that a locomotive cannot earn or do useful work while in the shed or repair shop, deferment of necessary maintenance attention is certain to result in failure while



VALVE SPINDLE CENTERING BRACKET

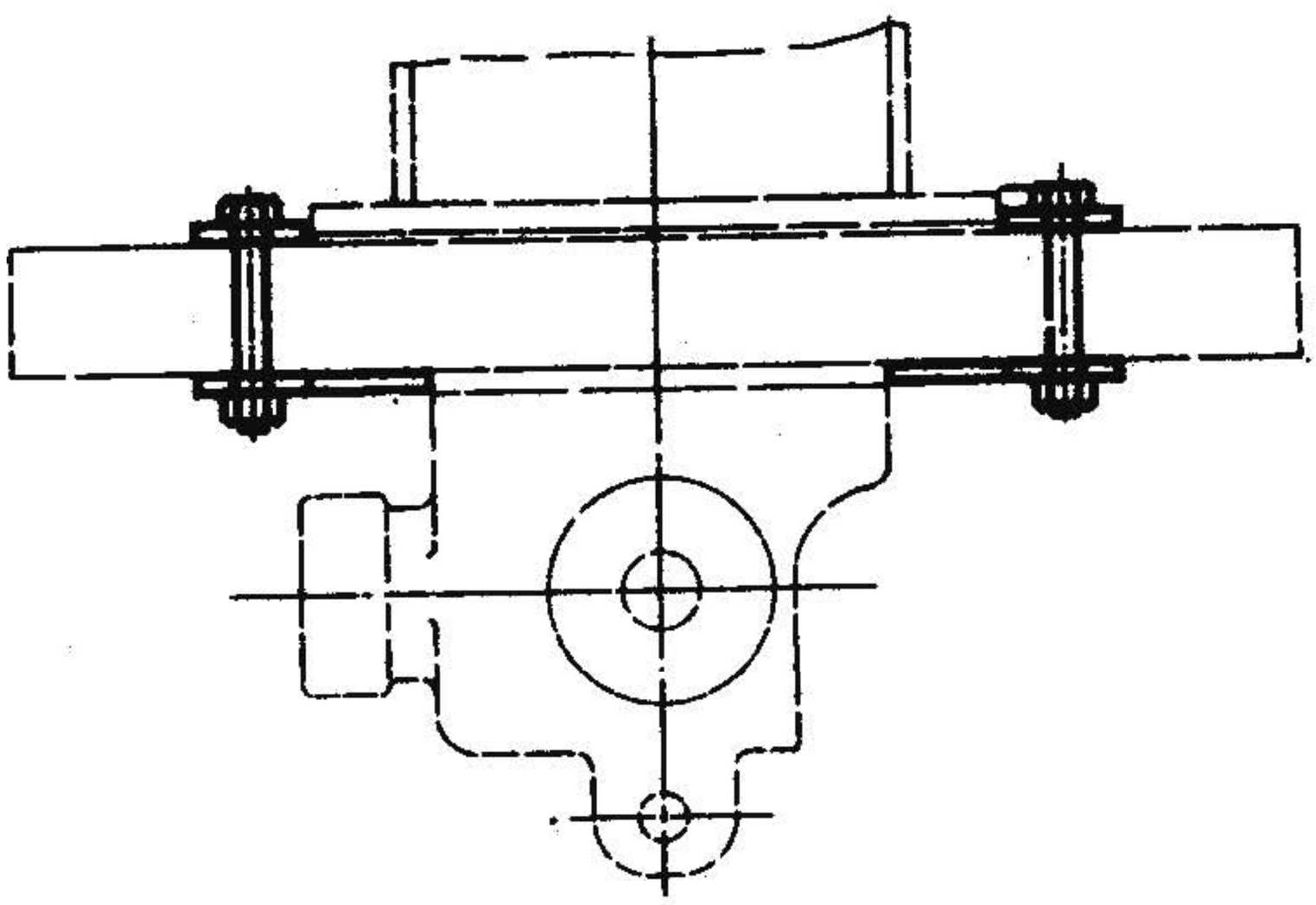


FIG 12

in traffic and still bigger repair jobs. The "stitch in time" applies with special force to railway locomotives since reliability is the first essential in successful railway working.

Cylinders.

The front cylinder and steam chest covers should be removed at intervals of 10 weeks or 10,000 miles, whichever is the shorter period, and a thorough examination should be made. At every examination the special form (Form GR 2) should be completed. A specimen of this form appears at the end of this manual and may at first sight appear too detailed. The information called for is essential to the proper forecasting of repairs and is the only possible basis for decisions on whether the period between examinations should be extended or reduced.

As mentioned earlier in these pages, it is not necessary to disconnect the piston rod from the crosshead to make an examination of the cylinder or to renew piston rings. All that is required is to remove the gudgeon pin and push the crosshead up to the piston rod gland as this will bring the piston outside the cylinder. Care must be taken to provide support for the piston rod in this extended position by placing a bar across the cylinder cover studs under the rod. Good tradesmen will see that the bar is well wrapped to avoid damage to the piston rod.

Removal of carbonaceous deposits from the steam passages is very easy since removal of the steam chest cover is equivalent to taking away part of the exhaust passage as its unusual shape indicates. The very short steam chest liners have steam ports only as they do not extend over the exhaust passage. This makes for easy cleaning and renewal.

If lubrication of the cylinders appears inadequate the fact should be reported on the form.

Note that the piston rod is reduced in diameter over that portion which does not work in the gland. This

reduction guards against the formation of ridges and at the same time shows the limit of wear which can be allowed. When the wearing part of the rod is reduced to the diameter of the exposed part, it must be renewed.

The valve spindle is enlarged at the gland end to give a reasonable bearing and guide surface and allow the end connecting to the lead lever to pass through the gland. This enlarged portion is not solid with the rest of the spindle but is screwed on and made secure by welding. When the diameter is reduced to 3.9/16″ it must be renewed but it will be seen that this does not entail renewal of the whole spindle.

Limits of wear for the cylinder barrel and steam chest liners will not enter into consideration for many years and are set down here only as a matter of interest. The cylinder barrel may require re-boring to correct inequalities of wear after long service but when the bore reaches $14\frac{3}{4}$″ diameter the cylinder should be replaced. Steam chest liners originally 8″ bore must be renewed when worn to $8\frac{1}{4}$″ bore.

Crosshead and Slidebars.

The slidebar construction though unusual, is simple and central support is provided so that bending of the slidebars under load cannot occur. This ensures that the full surface of the crosshead slippers will be effective and even wear will result.

Shims are provided between the slidebar support and the top slidebar, also between the bottom slidebar and the distance piece separating it from the top bar. These shims afford a ready means of adjustment if used with care.

The total clearance between crosshead slippers and slidebars is 0.012″ with all parts new and when this clearance has increased by wear to 0.035″ adjustments should be made. First both the slidebars and the crosshead slippers should be tried for straightness and

flatness and trued up as may be found necessary. The next step is to adjust the slidebars to provide a running clearance of from 0.010″ to 0.012″. In doing this it is most important to see that the true alignment of the slidebars is maintained. It is quite easy to simply reduce the space between bars by removing shims but this may force the crosshead to ride higher than its true level and hot running and further repairs are certain to follow.

Start by measuring the height from the centre of the gudgeon pin to the working surface of the top slipper. This height for new unworn slippers is $8\frac{1}{2}$″ and the difference between $8\frac{1}{2}$″ and the measured height plus the wear of the slidebar itself is the amount of adjustment required for the top slide bar and this adjustment can be made by changing the shims between the bar and its support. Five shims are provided—one 10 BG (0.125″) thick, one 16 BG (0.062″) thick, and three 4 BG (0.025″) thick. The following examples show how adjustments can be made in steps of 0.012″ by changing shims starting in each case with the original condition:—

1. Add one shim 16 BG .. .. 0.062″
   Remove two shims 24 BG .. 0.050″

   Adjustment .. .. 0.012″

   Total of shims is then one 10 BG
   two 16 BG
   one 24 BG

2. Add one shim 24 BG .. .. 0.025″
   Remove none .. .. .. 0.000″

   Adjustment .. .. 0.025″

   Total is then one 10 BG
   one 16 BG
   four 24 BG

3. Add one shim 16 BG .. .. 0.062″
Remove one shim 24 BG .. 0.025″

Adjustment .. .. 0.037″

Total is then one 10 BG
two 16 BG
two 24 BG

4. Add one shim 10 BG .. .. 0.125″
Remove three shims 24 BG .. 0.075″

Adjustment .. .. 0.050″

Total is then two 10 BG
one 16 BG

5. Add one shim 16 BG .. .. 0.062″
Remove none .. .. .. 0.000″

Adjustment .. .. 0.062″

Total is then one 10 BG
two 16 BG
three 24 BG

6. Add one shim 10 BG .. .. 0.125″
Remove two shims 24 BG .. 0.050″

Adjustment .. .. 0.075″

Total is then two 10 BG
one 16 BG
one 24 BG

7. Add one shim 16 BG .. .. 0.062″
Add one shim 24 BG .. .. 0.025″
Remove none .. .. .. 0.000″

Adjustment .. .. 0.087″

Total is then one 10 BG
two 16 BG
four 24 BG

8. Add one shim 10 BG .. .. 0.125″
Remove one shim 24 BG .. 0.025″

Adjustment .. .. 0.100″

Total is then two 10 BG
one 16 BG
two 24 BG

9. Add one shim 10 BG .. .. 0.125″
Add one shim 16 BG .. .. 0.062″

0.187″
Remove three shims 24 BG .. 0.075″

Adjustment .. .. 0.112″

Total is then two 10 BG
two 16 BG

10. Add one shim 10 BG .. .. 0.125″
Remove none .. .. .. 0.000″

Adjustment .. .. 0.125″

Total is then two 10 BG
one 16 BG
three 24 BG

It will be obvious that the distance between bars can be adjusted in similar manner except that in this case the adjustment is to reduce the total thickness of shims. One example will be sufficient—

Remove three shims 24 BG .. 0.075″
Add one shim 16 BG .. .. 0.062″

Adjustment .. .. 0.013″

All shims are made from black sheet steel and stocks of very accurately ground shim steel are not required. There may be occasions when the use of thinner shims is advantageous and to assist selection, the following

are the standard thicknesses of black close-annealed steel sheets:—

10 BG	..	..	0.125″
11 BG	..	..	0.111″
12 BG	..	..	0.099″
14 BG	..	..	0.078″
16 BG	..	..	0.062″
18 BG	..	..	0.050″
20 BG	..	..	0.039″
22 BG	..	..	0.031″
24 BG	..	..	0.025″
26 BG	..	..	0.020″
28 BG	..	..	0.016″
30 BG	..	..	0.012″

(Note that thickness is stated as "BG" not "BWG")

On no account should shims be placed under the crosshead slippers which must at all times be fastened securely to the crosshead.

When slidebars are worn to $\frac{5}{8}$″ thick ($\frac{1}{8}$″ wear) they should be replaced.

When crosshead slippers are worn to $\frac{3}{8}$″ thick ($\frac{1}{8}$″ wear) they should be replaced. The heads of screws securing the slippers to the crossheads should be soldered after tightening to ensure that they will not turn.

When fitting new shims for the top slidebar make sure that oil holes are drilled.

The gudgeon pin is a tapping fit in the crosshead and is held against turning. The nuts must be kept firmly tightened and the split pin must be fitted carefully to bed against the nut without slack. Any slackness of the gudgeon pin in the crosshead, however small, should be reported specially and dealt with at once. The only cure is a new gudgeon pin fitted into reamed holes. Provided the gudgeon pin is kept properly tightened there should not be any need for renewal until the bearing surface for the connecting rod brass is worn to $2\frac{3}{8}$″ dia. ($\frac{1}{8}$″ wear).

From the nature of its work a gudgeon pin must always tend to wear oval but it is impossible to make a satisfactory job by attempting to fit a brass to an oval pin. When the pin is worn out of round 1/32″ it should be trued up in the lathe and wear should never be allowed to go beyond this point. Do not attempt to file the pin round as such a task is virtually impossible and unsatisfactory running is the only sure result.

Connecting and Coupling Rods.

The little end of the connecting rod is fitted with the ordinary type of brass in halves and an adjusting wedge. This familiar construction does not call for special comment since closing the brass to take up wear is an everyday running shed job. As mentioned above, no good purpose can be served by trying to close a brass on an oval pin and measurement of the gudgeon pin should always be the first step. Running clearance between brass and pin should be 0.005″ to 0.007″.

The big end of the connecting rod is fitted with a "floating" bush which is free to revolve inside a fixed cast iron bush. Initial clearances are 0.009″ to 0.011″ between floating bush and crankpin and the same between floating and fixed bushes. When these clearances have been increased by wear to 0.030″ the floating bushes must be renewed and the new bushes must be machined to give clearances not less than 0.009″ or more than 0.011″. Whenever renewal of bushes is required the crankpins should be checked over and any tendency to wear oval should be reported specially. Attempts to file an oval crankpin to be truly cylindrical are not just a waste of time but definitely harmful. It is virtually impossible to make a pin true by this means and almost impossible to produce a satisfactory bearing surface. Truing up should always be done in a machine and the surface of the crankpin should be brought to the highest polish possible. Where machines for truing crankpins are not available there is no option but to try

filing but this can never be regarded as anything better than a very poor makeshift.

Sideplay should not be allowed to increase beyond 3/32″ total and when wear has developed to this point the bushes should be renewed. Building up with white metal is not satisfactory and involves waste of valuable material which is in short supply.

Remember always that as slackness increases the rate of wear increases and do not allow slack to develop beyond the specified limits.

All coupling rods have floating bushes and the above remarks regarding clearances and renewals apply with equal force.

Coupled Axleboxes.

As shown in Figure 8 the axlebox brass is square—backed with a collar seating in the top of the cast steel axlebox to prevent side movement. The brass is not lined with white metal but is made of an alloy containing a considerable proportion of lead. This alloy gives a smooth long-wearing surface.

At intervals of 40,000 miles the wheels must be dropped and all axle journals, axleboxes and horn-cheeks must be examined carefully and the results reported on Form GR 3. A sample of this form appears at the end of this manual.

In no case must any one of these locomotives be kept in service for more than 40,000 miles between axlebox examinations. Officers in charge of the locomotives must adhere rigidly to this rule and refuse to be diverted from it by any consideration. Insistence upon regular maintenance and examinations is the only way to ensure satisfactory operation.

Experience probably will show that the period of service between axlebox examinations may be extended beyond 40,000 miles but no extension must be allowed until authorized by the Commonwealth Land Transport Board.

When wear develops to an extent calling for re-boring of axleboxes remember that fitting is a poor substitute for accurate machine work. Bedding down with hand scrapers is necessary only when machining is inaccurate. Boring of axleboxes should be done in a vertical lathe with a table specially balanced or in an engine lathe with a balanced faceplate. However the operation is performed, accuracy and a highly polished bearing surface are the two essentials.

Care in marking-off axleboxes for boring is very necessary and to make this easy a permanent centre has been placed in the frame plate on each side of every axlebox gap. Start by measuring the distance from the horncheek face to the permanent centre and if this distance is not the same on each side do not attempt to mark-off for boring until proper correction has been made. Where difference occurs this can be due only to uneven wear either of the horncheeks or the axlebox and the first step is to true up the horncheek faces to be square, parallel *and the same for both sides of the engine.* The latter point is most important since if the axle is not square with the frame, hot boxes must occur repeatedly. When the horncheeks have been dealt with, measure the clearance between axlebox and horncheeks. If the clearance exceeds 0.020″ the sides of the axlebox must be built up by means of bronze welding rod and then machined to gauge to give a clearance of 0.004″ to 0.006″. When this has been done the axlebox brass may be marked off from the permanent centre.

The practice of fitting axleboxes to be tight in the guides is definitely bad and should not be tolerated. Machining to give the clearance stated is the only satisfactory practice.

This procedure should not be necessary until the locomotive has been in service for at least eighteen months and probably much more. It is essential, however, that the clearance between axleboxes and horncheeks be not allowed to grow beyond 0.020″ and as a

precautionary measure the clearance should be checked every time a cylinder examination is made (at intervals of 10,000 miles).

When examining axleboxes pay particular attention to the condition of the wool rolls provided for underfeed lubrication. If the surface of the wool appears glazed, the whole lot should be renewed without hesitation. Earlier in these pages the need for care in making new rolls has been mentioned and this should have close attention as care in such details will pay dividends in trouble-free operation.

See that the horncheeks are well lubricated and that the trimmings are in place and not binding.

Sideplay in coupled axleboxes is of great importance and must not be allowed to develop beyond $\frac{3}{8}''$ total clearance between wheel hubs and axleboxes. When wear has reached this limit the axlebox brasses should be renewed irrespective of whether they are worn on the journal bearing surface or not. Attempts to correct side-play by building up with white metal will only invite trouble since the soft metal will pick up abrasive dust and act as a lap. Building up with bronze welding rod is more likely to be successful but renewal of the brass is the best policy.

Bogie Axleboxes.

These are very similar in construction to the coupled axleboxes and should be treated in the same way.

Truck Axleboxes.

The form of brass and system of lubrication are similar to those in the coupled axleboxes and the treatment is generally the same. Note that these axleboxes are tied rigidly together and take care that both brasses for one axle are bored and bedded together. This is the only certain way of avoiding cross-corner bearing.

Valve Gear.

All pins and wearing surfaces in the valve gear are case-hardened and will not require attention for years if properly lubricated. Slack must not be allowed to develop and whenever any undue play is found pins should be renewed.

Spring Gear.

There are no pins in the spring gear except in the axlebox hangers. These pins should be renewed when any appreciable wear is observed.

All spring hangers are fitted with solid cotters and wear on these is very slight. It is only necessary to see that each cotter bears evenly in the hanger and on the spring or spring link bracket. Renewals will not be required until the engines have been in service for many years. Each cotter should be marked to its place before being removed and put back in the same place to avoid disturbance of axle loadings and the need for fitting.

Brake Rigging.

The brake rigging on each engine unit is compensated throughout and all brake blocks are adjusted by means of a single screw in the end of the main pull rod attached to the brake lever which is located just ahead of the leading coupled axle. Ample adjustment is provided and there is no excuse for excessive clearance between brake blocks and wheels. Too frequently brake gear pins are denied lubrication though it is obvious they are important working parts and should be oiled occasionally. Excessive slack in the brake rigging connexions leads quickly to excessive wear and worn pins should be renewed promptly. When the locomotive is in the shop or shed for examination or repair, maintenance staffs should oil the brake pins whether the running staff has done so or not.

With the simple means provided it is much easier to adjust the rigging than to renew half-worn blocks.

Westinghouse Equipment.

This is standard and will be familiar to maintenance staffs. The special instructions issued by the makers should be followed closely.

Main Steam and Exhaust Pipes.

All joints are metal to metal with coned lens rings and should be trouble-free. Breaking of joints is necessary only when the locomotive is shopped for general repairs or when renewal of corroded pipes eventually becomes necessary.

The cast iron bends attached to the cylinders should be left undisturbed as long as possible. From experience, examination once in ten years is sufficient.

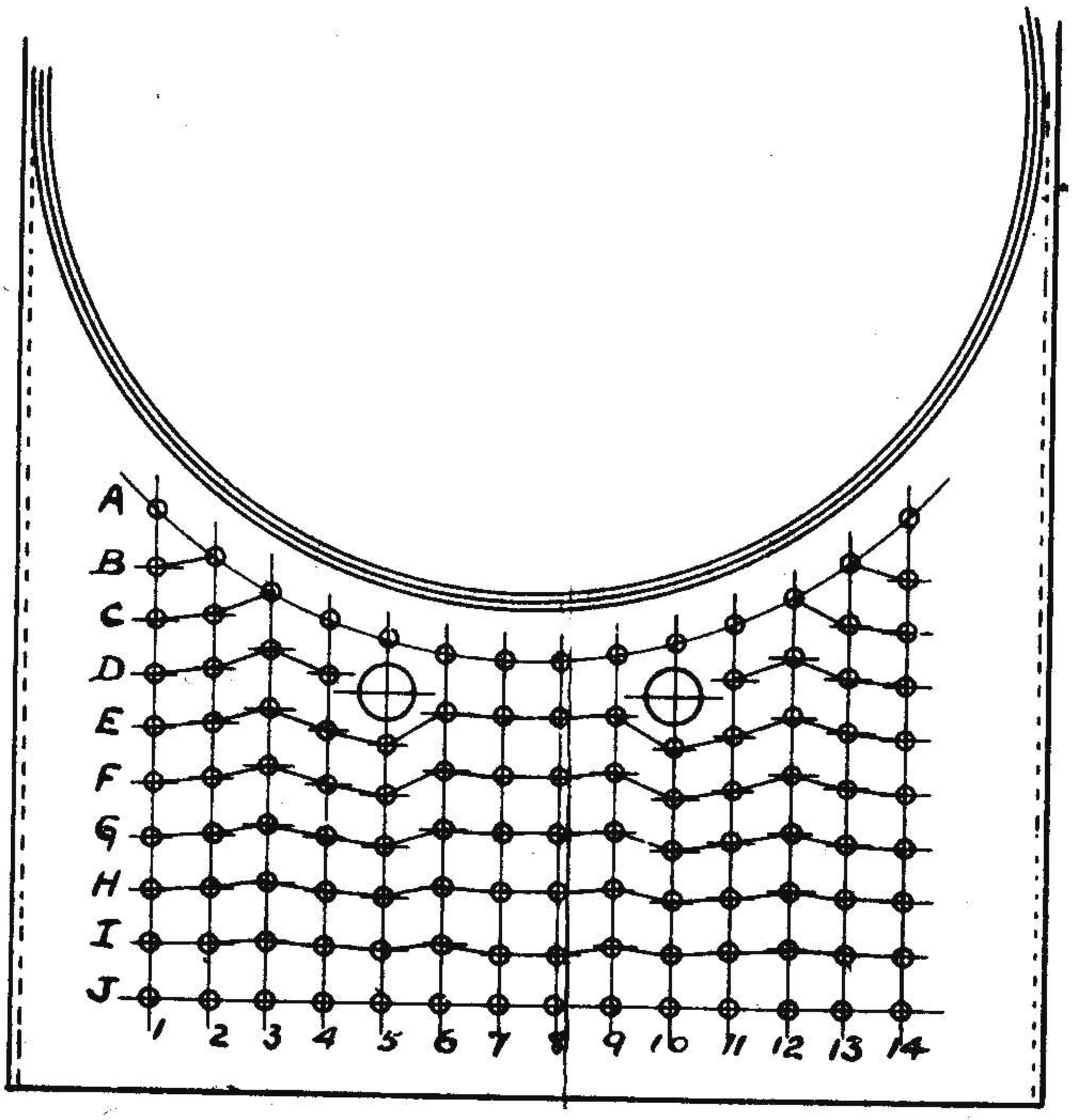
The ball joints under the pivot centres for live and exhaust steam should be left undisturbed as long as possible since owing to this very simple construction there is nothing to go wrong. There are no packed glands or split rings in these joints and the spherical faces are held in contact by springs. It is sufficient to make an examination when the engine is undergoing general repairs.

Expansion joints, which consist of packed glands, are provided for both live and exhaust steam lines and should require attention only at rare intervals. The main essential is to see that the glands are properly packed and tightened.

Boiler.

The boiler is the source of power and no amount of care and maintenance expended on the engine can be of any avail unless the boiler is kept in good condition. Rigid insistence upon a regular routine of inspection is essential and no consideration of any kind whatever can be allowed to interfere with this vital work. At times it is exceedingly difficult to resist demands that an engine be available for traffic and that boiler wash-out, &c., be deferred but, no matter how difficult, such

Commonwealth Land Transport Board Form No G.R.6

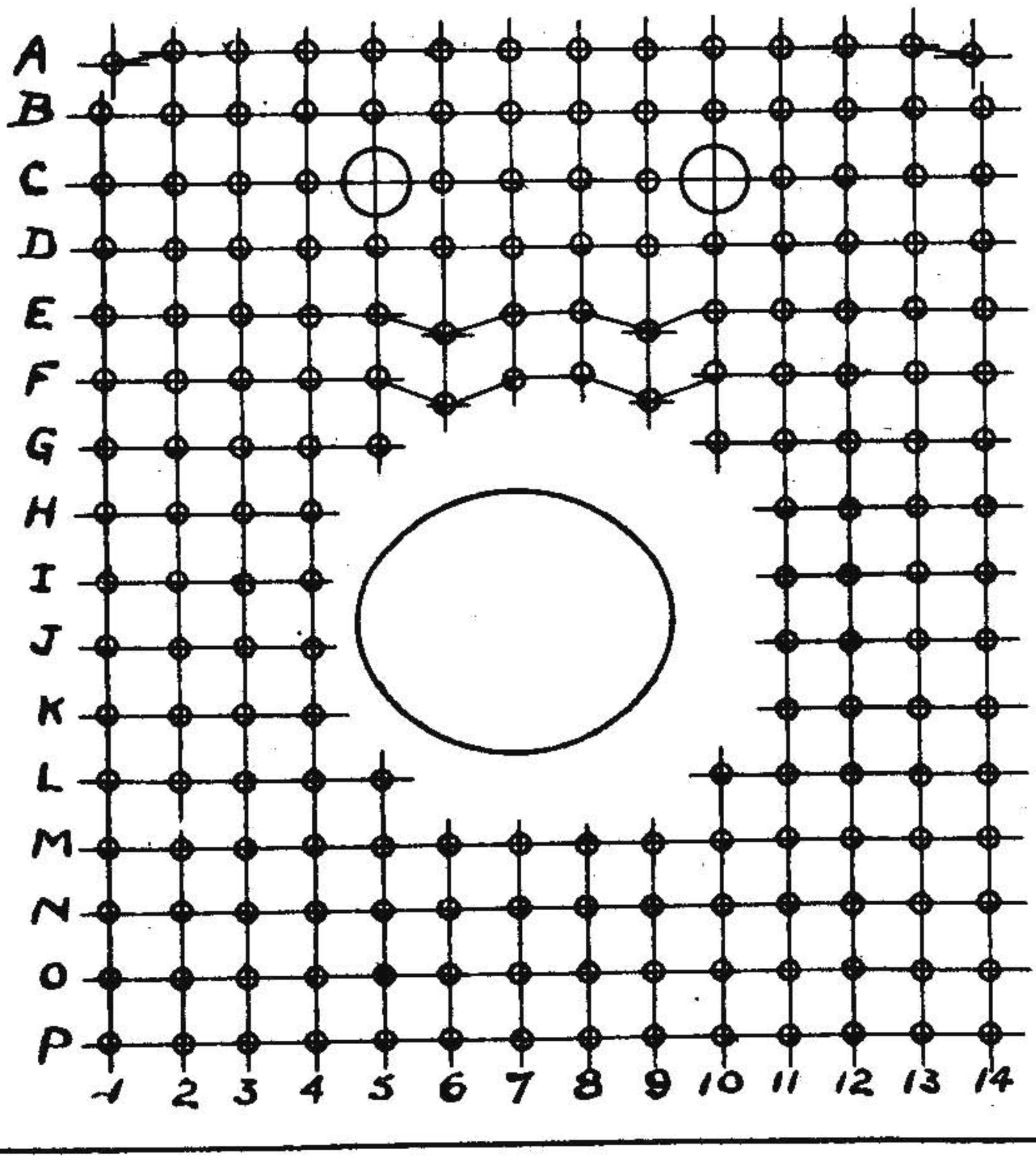


Throat Stays

Boiler No ASG _ _ _ _

Date. _ _ _ _

Commonwealth Land Transport Board. Form MGR.7.



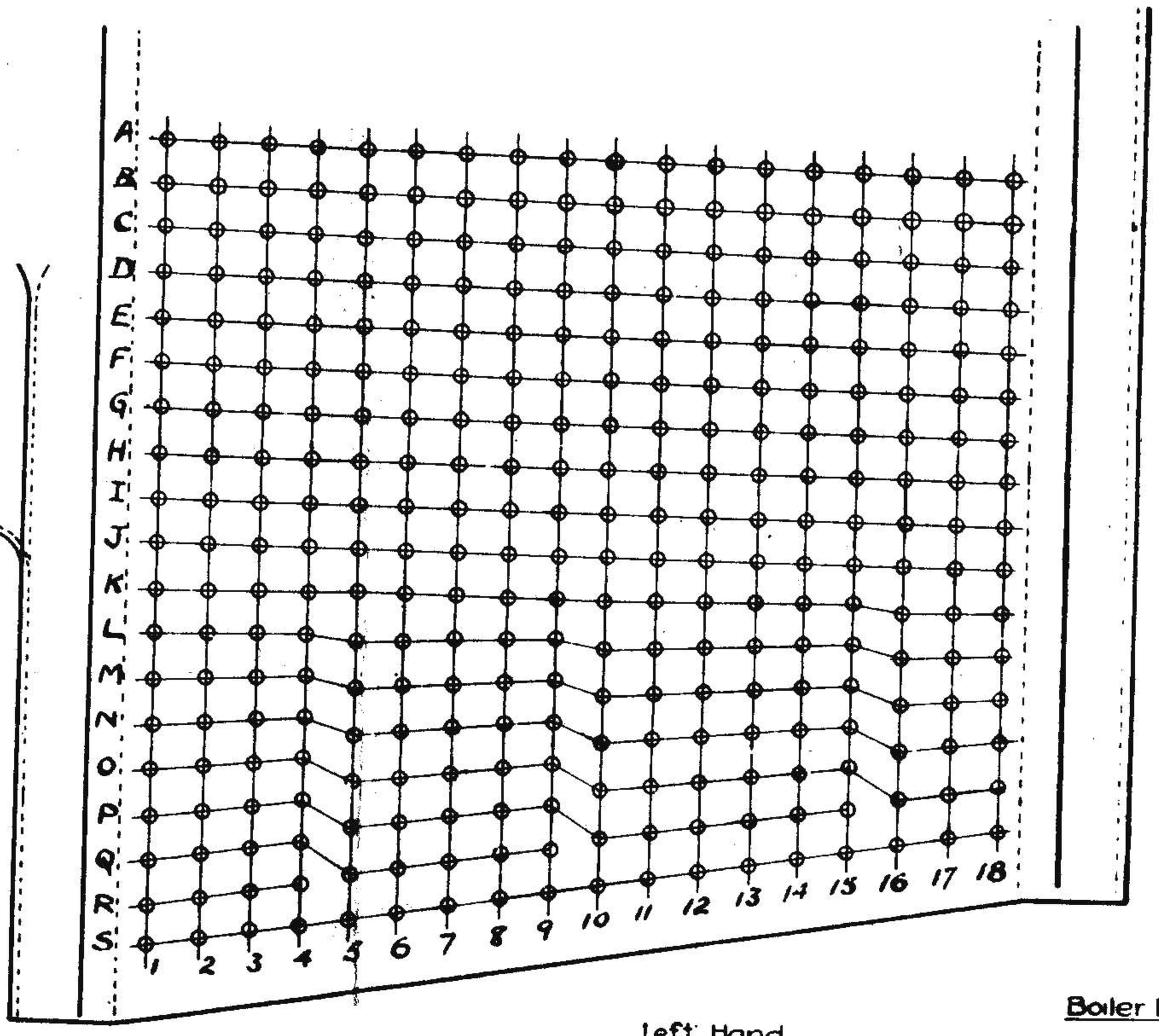
Back Stays.

Boiler. No ASG .....

Date. .....

Commonwealth Land Transport Board

Form N° GR5



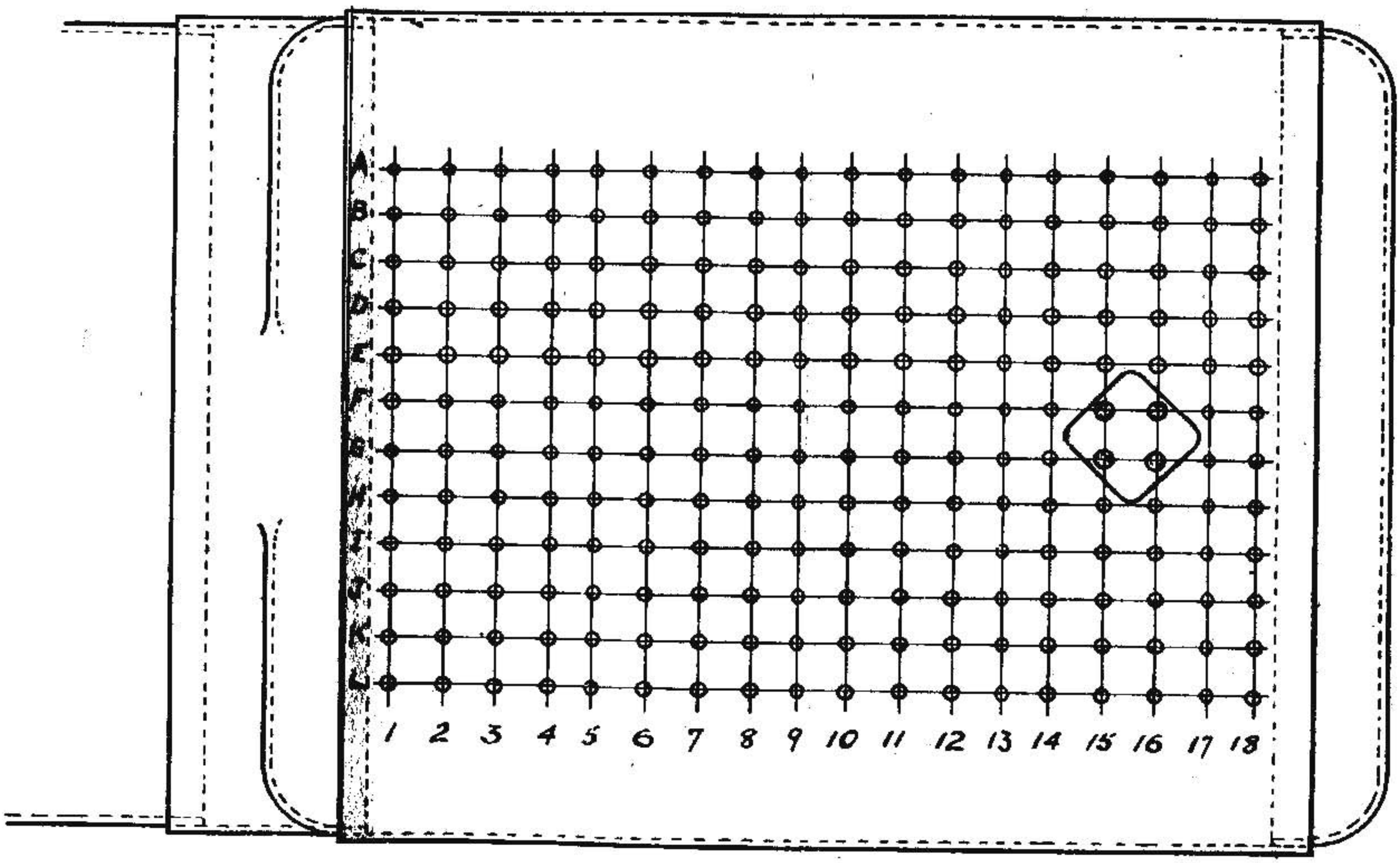
Side Stays Left Hand / Right Hand

Boiler N° ASG. . . .

Date . . . . . .

Commonwealth Land Transport Board

Form No GR 4



Crown Stays

Boiler No ASG_____

Date_____

demands must be resisted. No matter how well a boiler may be designed and built, it will quickly become useless and even dangerous if neglected.

It is expected that these locomotives will be kept in service continuously for six days of every week and that shed attention, particularly boiler washout, will be given every seventh day. On every washout day the boiler should be examined by a competent tradesman who will report on the general condition of the boiler. Points to be watched at these weekly inspections are: (*a*) extent of scale on plates, particularly firebox plates; (*b*) whether there is any appreciable corrosion of plates; (*c*) condition of crown stays and whether appreciable corrosion is present; (*d*) condition of water-space stays which should be hammer-tested over the regions where breakages usually occur first; (*e*) condition of firebars and brick arch; (*f*) condition of spark arrester and blast pipe. Any evidence of leaks from stays, rivets or joints should be reported specially and proper attention should be given before the engine is returned to traffic. All breakages of stays or measurable corrosion should be reported using the special forms to indicate the positions of such stays. Samples of these forms appear at the end of this manual and it will be seen that every crown stay and water-space stay can be identified by means of a letter and a number—for example, A4, B2, &c. In the course of his inspection the boilermaker will make sure that every plug has been removed and that washing-out has been done thoroughly. He will also see that every plug is coated with graphite and screwed back into place carefully so that there is no risk of cross-threading.

Where hot water washout plants are not available the pressure in the boiler must be reduced gradually by blowing-off through one of the injector steam valves while the other injector is used to fill the boiler to full glass. The blow-off cock must not be used to reduce

pressure except in serious emergency and in such case both injectors must be kept full on. When the pressure has been reduced to zero the water may be run out quietly by partial opening of the blow-off cock and the boiler should then be allowed to cool for at least four hours before any attempt is made to wash out with cold water.

While the boiler is standing empty all washout plugs must be removed to allow free access of air.

Care must be taken to avoid raising steam too quickly from cold. This boiler steams very easily and does not call for forcing. With water at half-glass or a little higher a light wood fire should be started or a small quantity of burning coal placed on the grate. The ashpan dampers should be opened but nothing else should be done to fan the fire. The blower should not be turned on until the pressure gauge shows 15 lb. per square inch. Time from first lighting-up to full steam pressure should never be less than two hours.

Once in every six months the boiler should be examined carefully by an authorized inspector who will make his report on a special form which is shown at the end of this manual. These reports will afford data on which a decision can be made as to when tubes should be withdrawn and a full internal inspection carried out. This should not be necessary until the boiler has been in service for six years.

All tubes are welded to the firebox tubeplate but are expanded only into the smokebox tubeplate. Provided that washing out is done regularly and thoroughly there should not be any trouble with tubes for some years. If one tube fails it is not enough to renew that tube only. Neighbouring tubes should be withdrawn and examined so that an opinion may be formed as to the extent of renewals required. In some cases it is advisable to withdraw a few other tubes so that the condition of all the tubes may be gauged.

When replacing a tube it must not be welded to the firebox tubeplate until it has been expanded thoroughly and the area to be welded has been cleansed properly of all dirt and scale.

MAINTENANCE ROUTINE.

Summarizing the foregoing notes the following routine should be observed carefully:—

ONCE PER WEEK:

Wash out boiler and make general examination.

ONCE EVERY FOURTH WEEK:

Check clearance between axleboxes and horncheeks.
Examine brake rigging.

ONCE EVERY 10TH WEEK OR EVERY 10,000 MILES:

Remove cylinder and steam chest covers and make thorough examination.

ONCE EVERY SIX MONTHS:

Boiler to be examined by Boiler Inspector.

ONCE EVERY 40,000 MILES:

Drop all wheels and make thorough check of all axleboxes, axle journals and horncheeks.

CONCLUSION.

These locomotives have been designed and built to meet an urgent need and if used with reasonable care will give good service and improve railway working. Although the type will be novel to many railwaymen it is as well to remember that it is just a steam locomotive to be operated and tended like any other steam locomotive. The design is based on sound orthodox principles to give a workmanlike job. Those who designed and built the locomotives have done their part and it is expected confidently that those responsible for operation and maintenance will do their part equally well.

FORM G.R. 1.

COMMONWEALTH LAND TRANSPORT BOARD.

PRELIMINARY REPORT ON ENGINE FAILURE OR DELAY.

Train delays due to locomotive causes are to be reported when in excess of 5 minutes for passenger trains or 10 minutes for mixed and goods trains. When the engine is unable to proceed with its train to destination the incident is to be reported as an engine failure. A detailed statement on the cause of failure and remedial measures taken must be supplied immediately investigation is completed.

Date of *delay / failure — Time

Engine No.

Train No. — *Passenger / Mixed / Goods — Load ____ tons. Schedule load ____ tons.

Section from ____ to ____ — Mileage

Place where failure occurred — ____ miles from

Grade at place of failure 1 in — *up. / down.

Speed at time of failure ____ m.p.h.

Train was running — *on time / ____ minutes late / ____ minutes early — when failure occurred.

Delay to train ____ minutes.

Cause of failure

Action taken

Steam pressure — The engine *was / was not steaming freely.

Condition of fire — The boiler *was / was not priming.

Sandgear working

Weather conditions

Investigation is *in hand. / considered unnecessary.

* Strike out words not applicable.

Signed

Position

Date

FORM G.R. 2.

COMMONWEALTH LAND TRANSPORT BOARD.

AUSTRALIAN STANDARD GARRATT LOCOMOTIVES.

CYLINDER EXAMINATION.

Cylinders are to be examined and results reported on this form at intervals of 10 weeks or 10,000 miles whichever is the shorter period.

NOTE—
"Front" refers to cylinders at smokebox end.
"Hind" refers to cylinders at bunker end.
L.H. means left hand when looking from cab towards smokebox.

Engine No. Depot

Next examination is due on Date of examination

Date of last examination

or at miles. Mileage since last examination

Total mileage to date

Cylinders—

dia. L.H. front *rebored to dia.
" R.H. " " " "
" L.H. hind " " "
" R.H. " " "

Pistons—

dia. L.H. front *replaced. renewed.
" R.H. " "
" L.H. hind "
" R.H. " "

Piston Rings—

L.H. front depth thickness *replaced. renewed.
R.H. " " " "
L.H. hind " " "
R.H. " " " "

Steam Chest Liners—

L.H. front cylinder outer end dia. *rebored to dia.
L.H. " " inner " " " " "
R.H. " " outer " " " " "
R.H. " " inner " " " " "
L.H. hind " outer " " " " "
L.H. " " inner " " " " "
R.H. " " outer " " " " "
R.H. " " inner " " " " "

Piston Valves—

L.H.	front	cylinder	outer	end			dia.	*replaced. renewed.
L.H.	„	„	inner	„			„	„
R.H.	„	„	outer	„			„	„
R.H.	„	„	inner	„			„	„
L.H.	hind	„	outer	„			„	„
L.H.	„	„	inner	„			„	„
R.H.	„	„	outer	„			„	„
R.H.	„	„	inner	„			„	„

Piston Valve Rings—

L.H.	front	cylinder	outer	end	depth		thickness	*replaced. renewed.
L.H.	„	„	inner	„	„		„	„
R.H.	„	„	outer	„	„		„	„
R.H.	„	„	inner	„	„		„	„
L.H.	hind	„	outer	„	„		„	„
L.H.	„	„	inner	„	„		„	„
R.H.	„	„	outer	„	„		„	„
R.H.	„	„	inner	„	„		„	„

GENERAL REMARKS: (State condition of lubrication, whether wear is even or uneven, extent of carbon deposits, &c.)

Signed

Position

Date

* Strike out words not applicable

FORM G.R. 3.

COMMONWEALTH LAND TRANSPORT BOARD.

AUSTRALIAN STANDARD GARRATT LOCOMOTIVES.

REPORT ON AXLEBOX EXAMINATION.

All wheels are to be dropped and all axleboxes examined at intervals of 40,000 miles.

Engine No.

Next Examination due at miles.

Date examined

Date of last examination

Mileage since last examination

Total mileage to date

Coupled Axleboxes.

—	Condition of bearing.	Diameter.	Rebored to .... diameter.	Condition of cheeks.	Total sideplay for axle.	Whether axlebox faces built up.
Front Engine—						
*L. Leading ..						
R. Leading ..						
L. Intermediate						
R. Intermediate						
L. Driving ..						
R. Driving ..						
L. Trailing ..						
R. Trailing ..						
Hind Engine—						
L. Leading ..						
R. Leading ..						
L. Intermediate						
R. Intermediate						
L. Driving ..						
R. Driving ..						
L. Trailing ..						
R. Trailing ..						
Bogie Axleboxes—						
†Front Engine ..						
Hind Engine ..						
Truck Axleboxes—						
†Front Engine ..						
Hind Engine ..						

* The term leading wheels is to be applied to the coupled wheels nearest the cylinders whether for front or hind engine.

† Give general remarks on condition and whether repair work is necessary. If repairs are done give particulars.

Coupled Axles.

—	Condition of journal.	Diameter.	Remarks.*
Front Engine—			
L. Leading			
R. Leading			
L. Intermediate			
R. Intermediate			
L. Driving			
R. Driving			
L. Trailing			
R. Trailing			
Hind Engine—			
L. Leading			
R. Leading			
L. Intermediate			
R. Intermediate			
L. Driving			
R. Driving			
L. Trailing			
R. Trailing			
Bogie Axles—			
Front Engine			
Hind Engine			
Truck Axles—			
Front Engine			
Hind Engine			

* State whether journal is worn parallel or taper and if well lubricated.

Coupled Axle Horncheeks.

—	Condition of faces.	Condition of lubrication.	Longitudinal clearance for axlebox.*	Whether faces re-dressed.
Front Engine—				
Leading ..				
Intermediate ..				
Driving ..				
Trailing ..				
Hind Engine—				
Leading ..				
Intermediate ..				
Driving ..				
Trailing ..				

* When clearance exceeds 0.020″, faces of axleboxes should be built up with bronze electrodes and re-machined.

Signed

Position

Date

INDEX.

INDEX—*continued.*

INDEX—*continued.*

By Authority: L. F. JOHNSTON, C'wealth Govt. Printer, Canberra.